POWER

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Theory and Practice

IN the days when the meetings of the A. S. M. E. were held, one at a time, in the little auditorium of the Society's house on West Thirty-first Street and men whose achievements have become a part of engineering history crossed swords there in discussion, one of the practical type who delighted in taking a rap at the theoretical man concluded an account of an instance in which the results did not check up with those indicated by the formula used with the sententious remark:

"Theory will agree with practice all right—*if the theory is correct!*"

And when the laughter had died away, Dr. Robert H. Thurston arose to remark in his inimitable way,

"And I should like to add, Mr. President, *if the facts are correctly stated.*"

There are many men who can give lessons in thermodynamics and electricity who could not start up and cut in a generating unit without mussing up the works.

There are many more men who suppose that the temperature of all steam is 212 degrees and who know the difference between a volt and an ampere only by gossip, who can make boilers steam and make engines and generators run as perhaps the men who designed them could not.

But they will always be constrained to subordinate operative positions because they do not know the basic principles that underlie the processes that they are conducting.

They have a supreme contempt for "book learning" and take unholy delight in the misadventures of the man who, knowing principles better than he does practice, gets into trouble through his unfamiliarity with the manipulation of the mechanism to which those principles apply.

The theoretical man can, if he stays on his own side of the fence and does not try to operate, get along without practice; that is manipulative practice. He must, it is true, know enough of the limitations of practice to apply his theory intelligently.

The practical man will not get away from punching a clock, carrying a dinner pail and collecting day's wages instead of a salary without a working knowledge of the theory and principles of his vocation.

Think over the list of those that you have seen advance to positions of responsibility and emolument and consider what their attitude has been toward study and learning.

I do not underrate the value of practical ability. When it comes to operating a plant, that knowledge of what to do and how to do it, which by long association becomes intuitive, is the first essential.

But when it comes to managing a plant, the man who, in addition to this practical operating skill, has the knowledge of why he does thus and so and why or whether it might not be better done otherwise, who is so well grounded in the fundamentals that he can diagnose troubles and meet an emergency, who can advise intelligently with regard to extensions and improvements and, by applying his technical knowledge, improve performance and efficiency, is the man who will be chosen when the call comes to greater things.

F. R. Low

Methods of Making Press Fits on Shafts That Insure a Good Job

How to Heat Rotors and Flywheels to a Medium Temperature Before Putting Them on Their Shafts—All Pressing Work Practically Eliminated

BY N. L. REA
Construction Engineer, General Electric Company

NOT so many years ago the writer advocated heating large rotors and flywheels with steam or hot water with the idea of reducing the trouble, time and expense of pressing them on their shafts in the field. This suggestion was received with considerable question, and it took no small amount of argument to get a trial of the scheme.

This method has worked so well and made such a material saving that the practice has been extended. We soon found that steam or hot water was not always available and that the mess they made was objectionable in some stations. Then, too, the increasing speed and size of machines made it necessary to increase the pressing allowances. The speed increase is especially important as experience and research has proved that the bores of high-speed rotors actually enlarge as they come up to speed. If you need three mils fit at speed, you may have to put the rotor on the shaft with several times that fit at standstill.

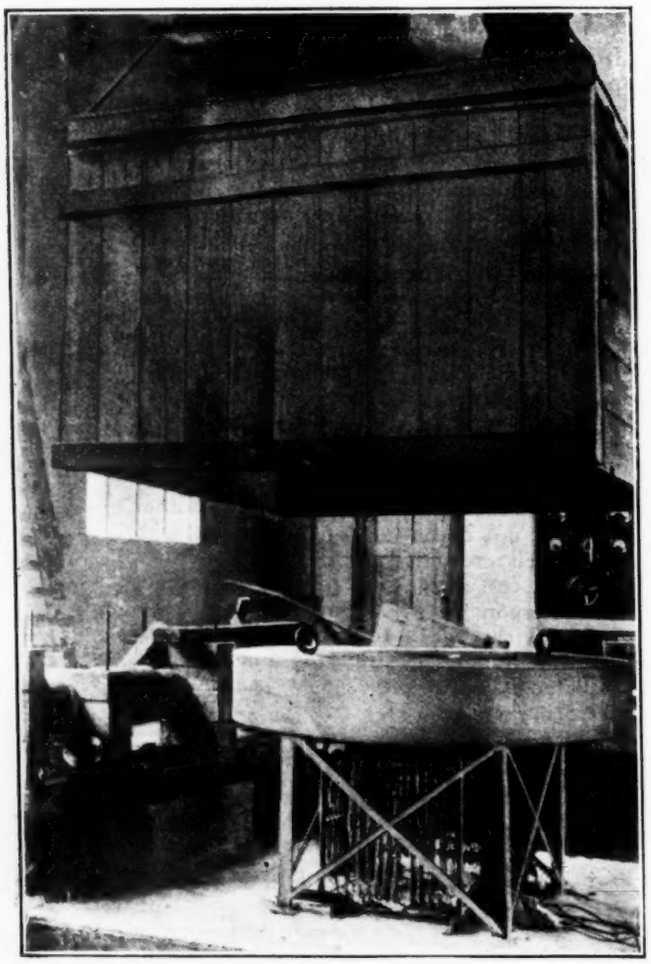


FIG. 1—OVEN READY TO BE LOWERED OVER FLYWHEEL AND HEATER

To make matters worse the high-speed rotors are of cast steel or are built up of steel plates, and steel on steel is the despair and terror of the experienced erector. Cutting is always to be feared, for if a chip starts to roll on either the hub or shaft, your pressure may double, and if your rig hasn't the necessary margin, you are in for a real time.

All these considerations led to experiments with electrical heaters, and repeated trials have developed a general method of procedure that may be varied to suit local conditions. An attempt will be made to give a general description of a typical case with the idea that it may serve as a basis for working out similar problems.

Several horizontal-shaft generators were designed with four-pole rotors built up of one-inch steel plate. These machines ran at 750 r.p.m., which necessitated a pressing allowance of 12 mils on a shaft diameter of 18 in. An angle-iron framework was made to support the rotor section a couple of feet above the floor, and electric heaters made of iron wire supported on porcelain knobs on an iron pipe framework were placed inside the supporting framework. The rotor sections were placed on this framework over the heaters and the oven proper lowered over the assembly. The oven consisted of a box made from packing-case lumber and lined with sheet iron. This sheet iron was separated from the inside of the box by battens to give an air space between the wood and the iron. Fig. 1 shows a flywheel on the framework and heater, and the oven being lowered into place. Bright galvanized iron or tin is better than black iron, as the bright surface tends to keep down radiation. This box has a full-sized opening in the bottom and a small hatch in the center of the top. The box was lowered over the rotor section and heater with the crane and the current turned on. The heater took about 15-kw. at 220 volts alternating current. The ultimate oven temperature was 185 deg. C. From time to time the hatch in the top of the oven was opened and the expansion of the bore checked. Twenty-four hours' heating gave an expansion of 30 mils.

In the meantime the shaft had been up-ended on the coupling face in a spare generator pit, braced securely and stops attached to prevent the first section dropping too far on the shaft. The pressing rig consisted of three 150-ton hydraulic jacks with common pump and manifold. A 6-in. steel plate with nickel-steel capbolts and the necessary blocking was in readiness for instant use in case of trouble. The end of the shaft was drilled and tapped for the nickel-steel bolts.

As things turned out, all the sections were dropped on of their own weight and the pressing rig was not

used. The intended scheme of using the rig is shown in Fig. 2. Speed is the criterion on this work, as the section *must be home* before the shaft and section equalize their temperatures.

On one installation where the crane was hand-operated and very slow, the oven and heating coils were arranged so they could be picked up with the rotor section and the heat kept on until the section was dropped home.

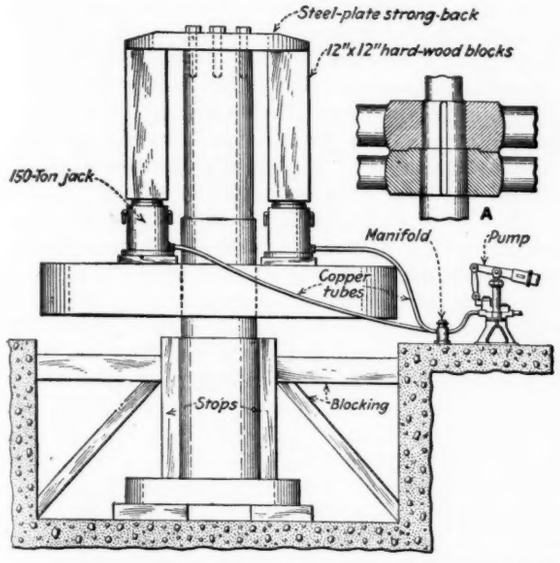


FIG. 2—ARRANGEMENT OF EQUIPMENT FOR PRESSING ON ROTOR IN CASE IT SETS BEFORE REACHING CORRECT POSITION

In another case a cold section was centered over the shaft and reference marks were made with white paint on the crane's track and truck and on the carriage and girder. The crane operator could set to these marks almost instantly, and the hitches on the sections were adjusted before heating so that the sections would hang level when the oven was removed and the hot piece picked up.

The procedure should be as follows: The fit on the shaft should be cleaned and any burs on the shaft or keys removed with a fine file. The fit should be coated with a mixture of pure white lead thinned to the consistency of paint with a mineral-base machine oil. Do not use a vegetable or animal-base oil, as it may turn rancid and cause rusting.

The oven should be lifted off, the expansion of the bore checked with a pin gage and feelers or inside micrometers, then the section swung over the shaft and lowered to its final position. The next section should be placed in the oven and the heat turned on. In general one section every twenty-four hours is about right. In any case the section in place and the shaft should be cooled to room temperature before another section is placed. *This is important.* The sections contract along the shaft as well as in diameter and if two hot sections are placed on the shaft at the same time, the outside will, naturally, cool first and grip the shaft. Then, as the cooling continues, the sections will pull apart and there will be a gap of several thousandths between them.

If a hot section is placed against a cold one, the side next the cold section will chill and grip first and the outside pull home along the shaft, thus giving a good job of assembly. The two sections should be lined up so that the keyways for the polepieces will line up and fasten in that position with short dummy keys in two slots diametrically opposite each other and at right angles to the shaft keys. Otherwise a very small clearance on the shaft keys may throw the pole keyways out of line enough to cause trouble. One ten-thousandth at the hub key may mean a large amount at the rim of the rotor, and the poles must go on and line up properly.

Another point must be looked out for or trouble will result. As a matter of convenience in shop handling and to simplify machining, the hubs of the various sections are sometimes rabbeted together as shown at *A* in Fig. 2. In some cases the designer or the shop foreman may assume that the sections will be pressed on cold while the erector will decide to heat the sections to save time and expense.

The recess may, therefore, be in the inside hub of the first section. This doesn't cause any trouble with the first section, but heating will expand the "plug" on the second section along with the rest of the piece, and the plug will be too big to enter the recess in the section below. The plug and recess serve no useful purpose in the assembly or operation of the machine, as the shaft and keys will keep the sections in line. The plug should be chipped or filed to give the necessary clearance. On machines designed for shrink fits the plugs are, or should be, always on top of the sections. By top is meant the side of the section that goes on the shaft last. as is the case of the bottom section of *A*, Fig. 2.

In another case an electric heater was made by bending iron rod into three concentric rings, threading

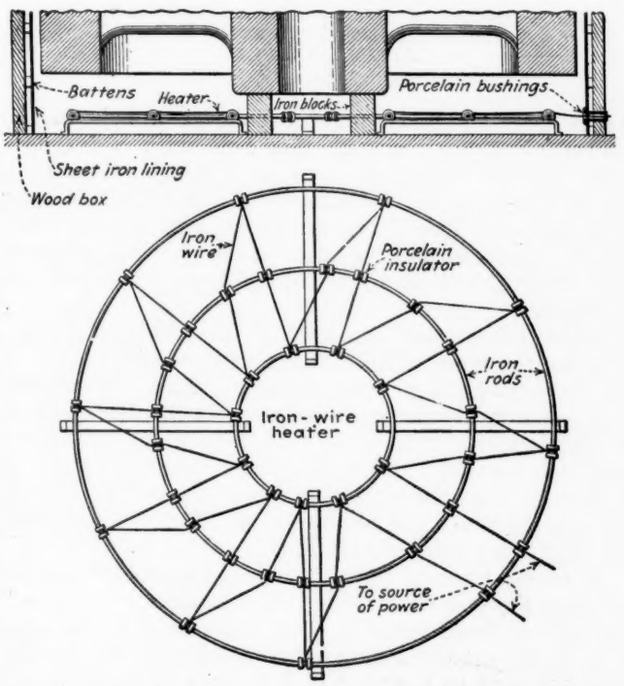


FIG. 3—HEATER MADE OF IRON WIRE AND HOW IT IS LOCATED UNDER ROTOR

porcelain knobs on these rings and supporting the rings on iron straps a few inches above the floor. The inside ring was slightly larger in diameter than the rotor hub and the outside one slightly smaller than the diameter of the rotor. The third ring was midway between the other two. Three pieces of No. 12 iron wire 400 ft.

long were laid together and tied with iron wire at frequent intervals. The bunch of wires was then zigzagged around the iron rings and tied to the porcelain knobs. The two ends were brought out adjacent to each other and the heater was ready for use. Fig. 3 shows the general scheme.

This heater took about 125 amperes at 220 volts. The oven was 5 ft. 6 in. square by 4 ft. high and reached a maximum temperature of 180 deg. C. Twenty-four hours' heating gave an expansion of 40 mils on a bore of 24 in. diameter. On another installation the rotor of a large motor was designed for a press fit of 0.004 in. The erecting engineer found seven 750-watt lamps and hung one of these between every pair of spokes and covered the assembly with a couple of tarpaulins. Twenty-four hours of this heating gave an expansion of eight mils.

Local conditions may make it advisable to drop the shaft through the sections. This has been done in some cases by making the oven over a hole in the power-house floor, closing this hole with a trapdoor large enough to take the shaft. The top of the oven was closed by a removable cover. A section of the rotor was heated to give the necessary expansion. The cover of the oven was removed, the bottom trapdoor dropped, the shaft picked up by the coupling and lowered into position.

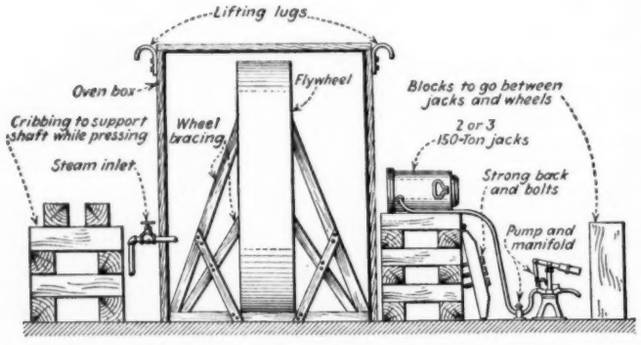


FIG. 4—GENERAL SET-UP FOR HEATING ROTOR IN VERTICAL POSITION BEFORE PUSHING SHAFT INTO PLACE

After the section had gripped the shaft, the shaft and section were lifted out, the next section placed in the oven and the process repeated. This method was used on a large vertical generator, as the crane equipment made it an easy matter to turn the assembled field end for end. This method has the disadvantage of tieing up the oven while the section is cooling enough to grip the shaft, and also makes it difficult to use jacks quickly if a section should stick.

If vertical rotors for waterwheel generators are assembled top end up, the big thrust washer, or "driver," of the step bearing can be kept in a corner of the oven and can be dropped on, quickly locked with the circular key and used as a strong back in case of trouble.

Where handling facilities are poor, it may be advisable to block the rotor sections of a horizontal machine on edge. Place the oven over it and arrange to bring the shaft to the rotor. The shaft can be threaded partly through the rotor, rested on blocking, the hitches changed and the shaft swung home. Fig. 4 shows the outline of the scheme with a section in the oven, the jacks on cribbing, the strong back on the floor at the end of the crib and the blocking to hold the shaft while changing hitches. It is advisable to have the jacking equipment ready for instant use in case of trouble. In ninety-nine out of one hundred cases the jacks will not be required, but the hundredth case may give one a bad job if the jacks are not ready.

The foregoing is intended as a general outline of up-to-date practice and gives only a few of the many possible variations that will work and suit local conditions. Steam blown in the heating box; hot air supplied by a hot-air transformer drier, taking air from the bottom of the oven, passing it through the heater and blowing it back into the top of the oven; a hot-air furnace taking air from the bottom of the oven and discharging back into the top, or any electric heater will serve the purpose. The writer is opposed to using gas or oil fires for this purpose; the flame is too hot and the heat is liable to be localized and may cause serious distortion or even breakage. Many a man has used torches on a hub only to find that the bore was getting smaller instead of larger. The rim of the rotor did not heat up as fast as the spokes and hub, and the only place the expansion could go was inward.

Uniform and fairly slow heating is requisite for success with this method, and steam blown in the oven under low pressure, as indicated in Fig. 4, undoubtedly gives the best heat distribution. The coldest part of the wheel will condense the most steam and take up heat the fastest. This equalizes the heating, but the condensation makes a mess that may be objectionable and the limit of temperature is probably around 90 deg. C. This may not be high enough for shrinks fits and is, of course, out of the question with a wound rotor or a field with the poles in place.

If electric heaters are used on a wound rotor or assembled field, a slight amount of ventilation should be allowed to carry off any moisture that may be in the windings. You kill two birds with one stone, expand the bore and partly dry the windings at the same time.

The heater and oven should be arranged to permit an air circulation around the piece to distribute the heating. The amount of power required is small. Heaters in practice have ranged from 5 or 6 up to 30 kw., and 10 or 12 kw. ought to take care of the biggest job if care is taken in building a tight oven box.

The expansion of steel spider bores is, approximately, 0.0005 in. per inch of diameter for each 100 deg. C. used. This expansion appears to be fairly uniform from the ordinary room temperatures up to around 200 deg. Heating above this is a waste of time and money, as the rate of expansion apparently drops rapidly.

It should be remembered that these figures are approximate, as they were obtained in actual practice when the work in hand was getting the section on instead of checking empirical formulas. The expansions given are actual readings taken by skilled men and are accurate to within a thousandth of an inch.

In checking expansions, keep the pin gage or inside micrometer lying on the shaft or cold section when not in use and work quickly when measuring the bore of the hot section.

In a recent case the pin gage was laid on the hot hub while the bore was wiped out, and when the bore was checked the pin had heated enough to spoil the reading. The piece had to go back in the oven for several hours before they dared drop it home. If you haven't inside "mikes," make a pin gage the exact size of the bore cold and use thickness gage or "feelers" under one end of the pin to measure the expansion.

Starting Direct-Current Motors—Current-Limit Type Controllers—I

By CHARLES A. ARMSTRONG

TWO types of series-lockout contactors as used on automatic motor-starters are described and the operation of two controllers using these types of contactors is given in detail.

A TYPE of controller that has found wide application during the last ten or fifteen years is one that operates on the current-limit principle. With this type the coils that close the contactors and cut out the resistance are connected in series with the armatures, therefore the greatest current values in the coils will be obtained at the instant of starting. Ordinarily, magnetic switches are so designed that the greater the current through the closing coil the quicker they will close. In the current-limit types the magnetic circuit of the contactor is so designed that if the current exceeds a certain value, the switch will hold open, in other words is magnetically locked open. Since the contactor coils are in series with the armature and the contactors will lock open if the current exceeds a predetermined value, these contactors are generally known as the series-lockout type.

The operation of one type of this contactor, as used by the Electric Controller & Manufacturing Co., is illustrated in Figs. 1 and 2. The metal frame of the contactor is similar to that for most any other type of magnetic switch, but a somewhat different type of plunger is used, it being made of two sections, a long part P and a short thick section P'. The short thick section is connected to a contact disk D by a brass stem B. An adjustable iron sleeve S is used to adjust the air gap G to change the current value at which the contactor will close.

When the line switch is closed, a maximum current passes through the motor, which also passes through the contactor coil. The plunger P is of such a cross-section that when the current exceeds a certain value, it becomes saturated and any increase in current above this value causes lines of magnetic force to flow across the air gap G, as indicated in Fig. 1. The lines passing through the air gap G into P', along with the weight of the plunger tend to prevent it from being lifted, where the lines passing across air gap G' into the frame F tend to lift the plunger. The contactor is so designed that when the current flowing in the coil exceeds a

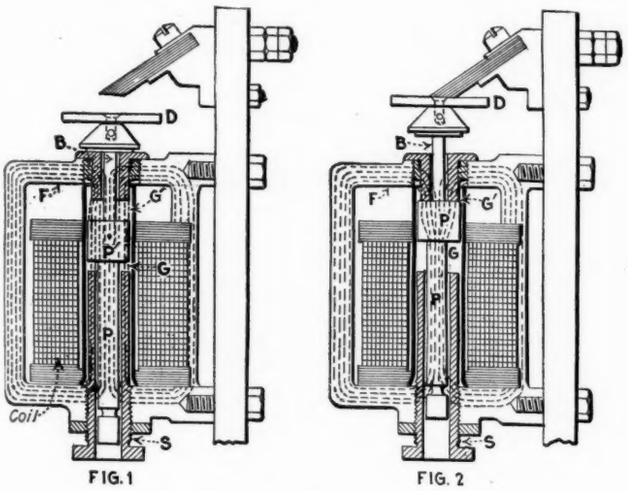


FIG. 1

FIG. 2

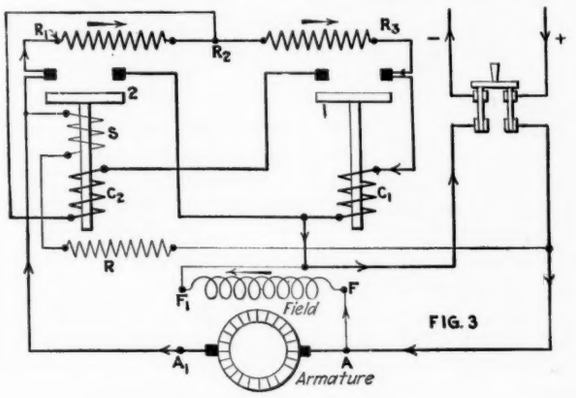


FIG. 3

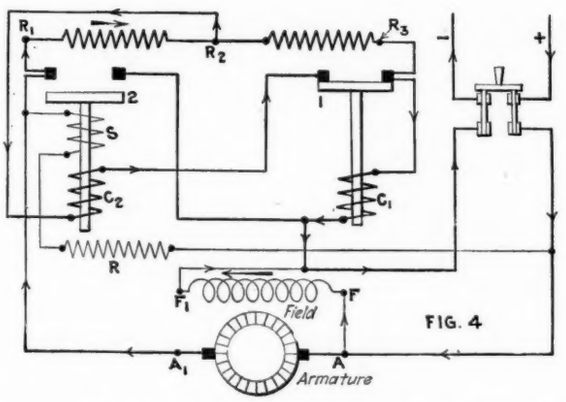


FIG. 4

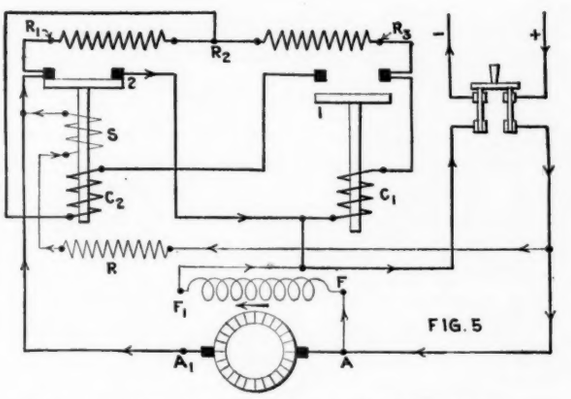


FIG. 5

FIGS. 1 TO 5—LOCKOUT-TYPE CONTACTOR USING ONE C IL AND CONTROLLER CONNECTIONS

certain value, the downward pull across gap G plus the weight of the plunger is greater than the lifting force across gap G', and the contactor remains open.

As the motor increases in speed, the current through the coil decreases and also the lines of force in air gap G. When the current decreases to a predetermined value, the pull in gap G will decrease to a value where the pull across gap G' will be sufficient to lift the plunger as in Fig. 2. Under this condition practically

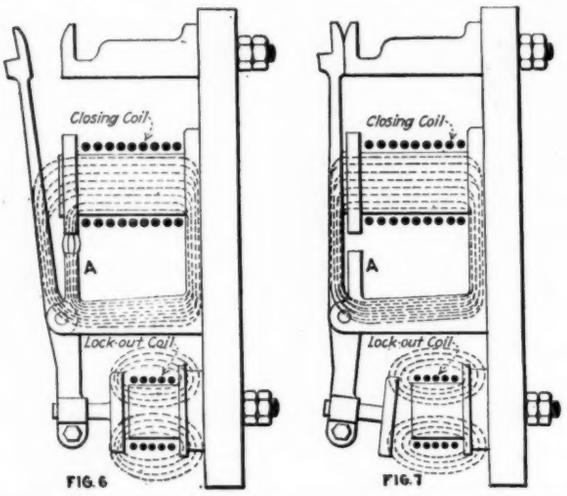


FIG. 6 FIG. 7

FIGS. 6 AND 7—LOCKOUT-TYPE CONTACTOR USING TWO COILS

all of the lines of force pass into plunger P and very few go across gap G.

Adjustment can be made as to the value of current that the contactor will close at, by screwing sleeve S up or down. Raising S decreases air gap G and causes more line of force to flow across this gap for a given current, and increase the downward pull. Consequently, raising sleeve S will delay the action of the contactor, where lowering it will allow the contactor to close at a higher current value. The maximum value at which this contactor can be adjusted to close, is about four times the minimum value.

Wiring Diagrams

In Fig. 3 is shown a wiring diagram for an automatic controller having two contactors similar to that in Figs. 1 and 2. When the line switch is closed, current flows from the + side of the line through the armature, the starting resistance between R_1 and R_3, coil C_1 and to the — side of the line. There is also a circuit through the field winding as indicated by the arrowheads. The inrush of starting current through coil C_1 locks contactor No. 1 open as described in Figs. 1 and 2. As the motor speeds up, the current decreases to a value where coil C_1 can close its contactor as in Fig. 4. When this contactor closes, it short-circuits the resistance between R_2 and R_3, so that the armature circuit is from R_1 to R_2 through coils C_2 and C_1 to the — side of the line. Cutting out the section of resistance between R_2 and R_3 allows the current to increase to a value that causes coil C_2 to lock No. 2 contactor open. As the motor increases in speed, the current decreases in value to where coil C_2 closes its contactor and short-circuits the section of resistance between R_1 and R_2. The armature is now connected across the line through contactor No. 2, as indicated in Fig. 5. This cuts both coils C_1 and C_2 out of circuit, which allows contactor No. 1 to drop open. No. 2 contactor is held closed by the shunt coils S the circuit of which is from the + side of the line through resistance R, coil S, contactor No. 2 and to the — side of the line. Closing coil C_2 cannot be depended upon to hold its contactor closed, since if the motor were operating at light loads the current might decrease to such a low value that the contactor would open. For this reason the series coils are cut out of circuit and the shunt coil is used for holding the contactor closed. The shunt coil S is not strong enough to close the contactor, but can hold it closed after the series coil has done the closing.

In this type of controller if for any reason the motor was stalled, the starting current would not decrease and the contactors would remain locked open. On the other hand, if the motor were lightly loaded, it would pick up speed rapidly and the contactors would close quickly. On a heavy load acceleration would be slower, consequently the starting current would decrease slowly and the contactors would require a longer time to close and cut out the starting resistance. From this it is seen that with this type of contactor the resistance is cut out of circuit to meet the load conditions on the motor, light loads requiring a shorter time than heavy loads.

Lockout Contactors Using Two Coils

Another series-lockout type of contactor, Fig. 6, is that used by the Cutler-Hammer Manufacturing Co., in which two coils are used. One of the coils acts as

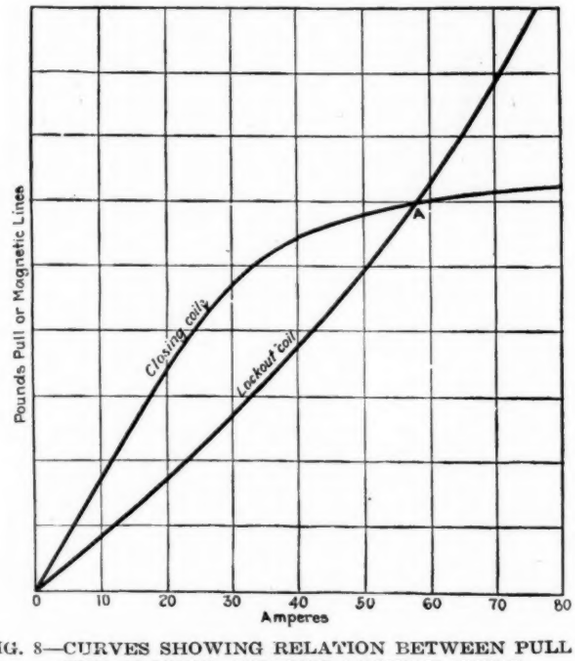


FIG. 8—CURVES SHOWING RELATION BETWEEN PULL OF THE CLOSING AND THE LOCKOUT COILS, FIGS. 6 AND 7

the closing coil and the other to lock the contactor open. The two coils are connected in series and in series with the armature. The lockout magnet has a long air gap, consequently the lines of force set up by this coil will increase, therefore the pull, almost in proportion to the current flowing in the coil, as indicated in Fig. 8. The closing coil has a short air gap in its magnetic circuit, consequently the line of force will increase at a high rate at first as the current increases, and as saturation is approached the increase

will be slow, similar to the way that the field builds up in an electric motor or generator, as shown in Fig. 8. At point *A* the pulls of the two coils are equal; to the right of *A* the pull of the lockout coil is greater than that of the closing coil, consequently the contactor will lock open. To the left of *A* the pull of the closing coil is greater than that of the lockout coil and the contactor will close.

In Fig. 6 is shown the general arrangement of the contactor parts. When the motor circuit is closed, there is a rush of current through the armature of, say, 70 amperes. This current flowing through the lockout coil creates a pull on the lower end of the contactor arm which is in opposition to that of the closing coil. The closing coil is also energized by the armature current and sets up lines of force as indicated by the dotted lines. Assume that the curves, Fig. 8, represent the pull developed on the contact arm by the two coils. With 70 amperes flowing in the coils, the pull of the lockout coil is greater than that of the closing coil and the contactor will remain open. As the motor increases in speed, the current decreases, as will also the pull of the magnets on the contact arm. Owing to the difference in characteristics of the magnetic circuits of the two coils, the pull of the lockout coil decreases faster than that of the closing coil, so that with 50 or 55 amperes flowing in the coils the pull of the lockout coil is enough less than that of the closing, so that the latter can close the contactor, as in Fig. 7. The projection *A* on the closing magnet is to provide a leakage path for the flux when the contact arm becomes saturated.

Figs. 9 to 11 are diagrams showing how a controller operates, having contactors as described in Figs. 6 and 7. When the switch is closed, as in Fig. 9, current flows from the + side of the line through coils C_1 and C_3 on No. 1 contactor through the starting resistance R_1R_3, the armature and to the — side of the line. The field winding is connected directly across the line, as indicated by the arrowheads. The inrush of current to the motor through coils C_1 and C_3 makes the pull of lockout coil C_3 greater than that of the closing coil C_1 and the contactor cannot close. As the motor increases in speed. the current decreases in value until the pull of C_1 is greater than C_3 and the contactor closes, as in Fig. 10. With No. 1 contactor closed, the armature circuit is through coils C_1, C_2 and C_4, through the starting resistance between R_2 and R_3, through the armature and to the — side of the line. Cutting out the section of resistance between R_1 and R_2 causes the armature current to increase in value again and make the pull of coil C_4 greater than that of C_3, so that contactor No. 2 is held open. As the motor increases in speed, the current decreases to a value where the pull of C_2 becomes greater than C_4 and No. 2 closes, as in Fig. 11, and cuts out all the starting resistance and the motor comes up to full speed. From Fig. 11 it will be seen that when both contactors are closed, lockout coils C_3 and C_4 are cut out of circuit, the circuit for the armature being directly through C_1 and C_2 the armature and to the — side of the line.

If the load were heavy on the motor, it would start slowly, consequently the starting current would decrease slowly and the contactors would remain open for a longer period. On the other hand, if the motor were starting light it might accelerate so quickly that the starting current would not reach the lockout value and the contactors would close quickly. In other words, the starting resistance will be cut out of circuit according to the load on the motor, being cut out slowly for heavy loads and quickly for light loads, which is as it should be. If the motor were overloaded so that it could not start, then the contactors would lock open until the load was reduced to such a value that the motor could start.

The next article will describe two other types of series lockout automatic starters for motors.

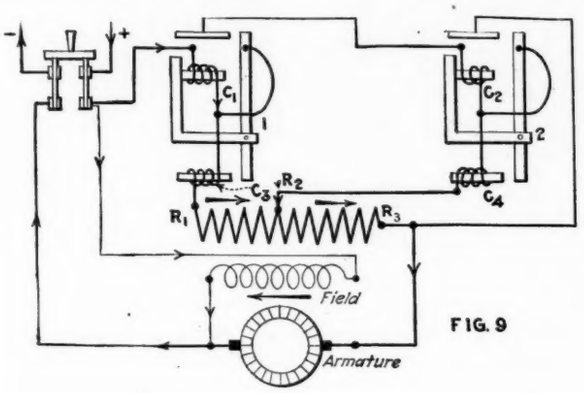


FIG. 9

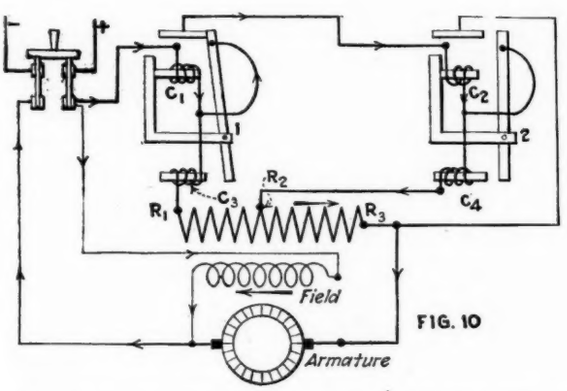


FIG. 10

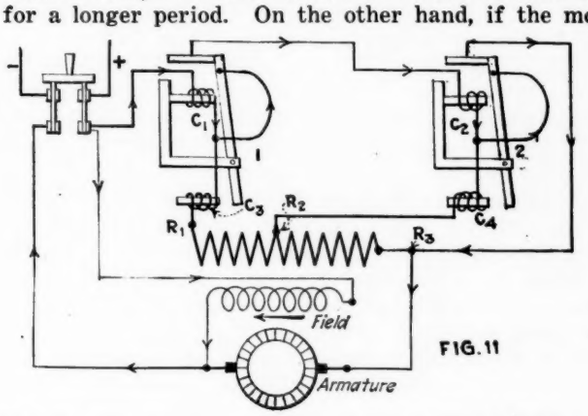
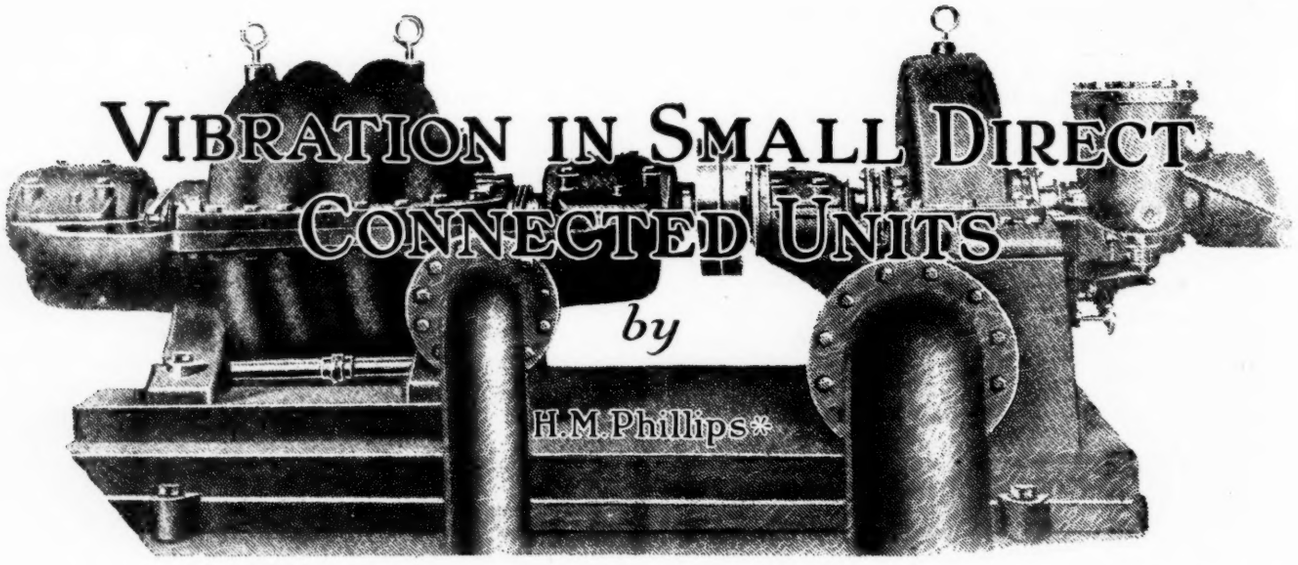


FIG. 11

FIGS. 9 TO 11—CONNECTION DIAGRAM FOR CONTROLLER HAVING LOCKOUT CONTACTORS, FIGS. 6 AND 7

Don't run an ammonia compressor with a high head pressure unless it costs more for water to keep it down than for coal to pump against it. Don't forget to purge the condenser of air and foul gases to keep down the head pressure. Don't neglect pumping the air out of the system before starting whenever it has been opened for repairs or other reasons.



VIBRATION IN SMALL DIRECT CONNECTED UNITS

by

H. M. Phillips*

THE high-speed unit, either turbine or motor driven, has the advantages of compactness and low first cost, frequently combined with high efficiency; but is generally more sensitive to misadjustment than slow-speed machines, so that a certain amount of vibration is sometimes in evidence when the machine is first set up, and in other cases may develop after a considerable period of operation. There are many engineers who attribute all vibration to the fact that the unit is "out of balance," which they consider an act of Providence or a necessary evil, and so long as the noise does not become unbearable and there is no very decided tendency to walk away with the foundation, they give the matter no further attention. As a last resort the manufacturer may be called upon to send an expert for rebalancing the machine, which necessarily means a sizeable bill for time and traveling expenses. Some engineers who have had one experience in balancing a high-speed set are not anxious for another. As a matter of fact vibration can generally be eliminated by any intelligent mechanic who looks carefully for the cause and goes about his work in a systematic manner employing patience and making note of all observations.

Vibration, in the writer's opinion, is more frequently caused by incorrect alignment of the bearings or a defective coupling than by a lack of balance in the moving parts. The trouble may easily have originated during the installation of the machine. The cast-iron bedplate on which the two parts of the unit are mounted is generally described by the manufacturer as "massive"; this may have every appearance of being so, and it may be massive in the sense in which the word is ordinarily used, but when subjected to any strains tending to cause deformation, it will be found surprisingly flexible. The shaft may be quite easily thrown out of alignment by an uneven bearing of the bedplate upon its foundation. To avoid trouble of this nature, the set should be supported while leveling by a sufficient number of steel wedges to avoid undue localized strains.

As a rule wedges should be placed near the foundation bolts, which are left loose until after the machine is grouted, while additional wedges are placed where the weight is concentrated; these should not usually be more than three feet apart and ought to be driven so as to distribute the weight as uniformly as possible. A sensitive level applied to all finished surfaces or "leveling pads" that can be reached should indicate good leveling at every point. In some cases the level will show true on one part but not on another, which may indicate a springing of the bedplate that can be remedied by a slight adjustment of the wedges; less frequently it is due to poor workmanship on the part of the manufacturer. The engineer must use his best judgment as to the most important parts to place level, or to devise some means of using special distribution of weight or pull of foundation bolts to flatten out the base. There is some difference of opinion as to the manner of disposing of the wedges after grouting; if they are removed, the bedplate may have a more uniform bearing on the grout, but the more generally accepted practice is to leave them in place, cutting off the projecting ends.

Before pouring the grout it is well worth while to check the alignment of the coupling, which is the really important feature; it is frequently possible to correct minor errors by adjusting the wedges that support the bedplate. In this connection the direct-connected units may be divided into three classes: (a) The three-bearing set with rigid coupling, frequently used for motor-generators; (b) the four-bearing set with rigid coupling, sometimes used for rather large motor-generators and some other types of machines; (c) the four-bearing set with flexible coupling, commonly found on centrifugal pumps, fans and various other types of machines. Of these three the latter is rather most likely to give trouble, and the same treatment it receives will serve, with minor modifications and omissions, for the others.

ALTHOUGH usually attributed to unbalance, vibration is often due to misalignment or coupling trouble, which can be corrected by comparatively simple means. Leveling bases and checking coupling alignment requires special care. Balancing at the plant, when necessary, may be accomplished by the engineer if the general instructions are carefully followed.

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The avowed purpose of the flexible coupling is to take care of errors in alignment between the two connected shafts. There are many very ingenious designs on the market, which serve their purpose more or less successfully when the error of alignment is extremely small. It is safe to say that the ideal flexible coupling is yet to be invented; one might even go so far as to predict that it never will be.

As a crude illustration of the difficulty involved, we

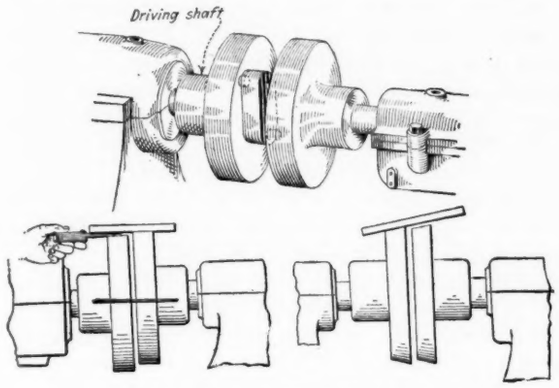


FIG. 1—ONE LINK COUPLING PRODUCES RECIPROCATING STRAINS

may consider the coupling illustrated in Fig. 1, where the two flanges are connected by a short open link. This coupling will possess the desired element of flexibility, but while the link is in the position shown, the torque of the driving shaft will tend to lift the driven, while a half-turn later the conditions will be reversed, causing a racking motion, producing much strain on the bearings and some vibration. Placing a second link 180 deg. from the first will equalize the drive as long as the shafts are in perfect alignment; but if the driving shaft is slightly raised, the link in the position shown will immediately take all the load, allowing the other to become slack and giving the same lifting action as before; with a rotation of 90 deg., the pull on the links will be equalized. If stiff springs are substituted for links, the action will be less marked, with less throwing of the shafts out of alignment, but it will not entirely eliminate the unequal pull on both flanges.

The ordinary flexible coupling is a modification of this idea and retains the inherent defect of an inequality of strain on the various members when the shafts are out of alignment; moreover, slight inaccuracies of workmanship or unequal wear may produce the same condition even where there is no error of alignment. Although the new coupling is not often defective, it should be cleaned up and examined as well as possible to make sure that it will function to the best of its ability; when trouble develops in an old machine, the coupling is quite likely to be the cause, and should be carefully overhauled.

Checking Alignment When Flexible Couplings Are Used

Alignment of the shafts is best checked at the coupling, the first step being to place a straight-edge across the flanges as shown at the left in Fig. 1, and thus measure any misalignment with the utmost care as well as at the bottom, so as to check if both flanges are of equal diameter. The straight-edge should next be placed on the side of the coupling, 90 deg. from the first position, where the alignment should be equally good for motor-generator sets or other pieces of apparatus in which the relative elevation of the two shafts is not likely to change after being put into operation. In the case of a turbine-driven unit the turbine shaft should be a few thousandths lower than the driven shaft, as the former will rise slightly, due to expansion, after steam is turned on. This example is one of the small number that offer a really legitimate excuse for the use of a flexible coupling.

Flange Diameter May Vary

Although it might be possible to make a rough estimate of the rise of the turbine shaft, it is hardly worth while to do so; the better way is to use one's own judgment in the original line up and then check the result after shutting down, while the turbine is still hot. Unfortunately, all couplings are not accurately machined; the two halves may vary slightly in diameter, or one or both may be slightly tapered. Application of the straight-edge at a point 180 deg. from its original position, will readily show any difference in diameter, which may be corrected for, by measuring the distance with a feeler gage or thin shims. Flanges that are slightly tapered can be detected on the original application of the straight-edge and the correct alignment established by the use of a "feeler gage" in connection with the straight-edge, as illustrated by Fig. 1, or by using a square as shown in Fig. 2. Revolve one flange 180 deg. and take the measurements again so as to check for a sprung shaft.

The use of a straight-edge, as described, gives a very good indication when the shafts are parallel, but cannot be depended upon to demonstrate the alignment when the shafts are inclined to each other, where the coupling flanges will assume the position illustrated to the right in Fig. 2. An error of this nature is readily detected by the use of a feeler between the faces of the

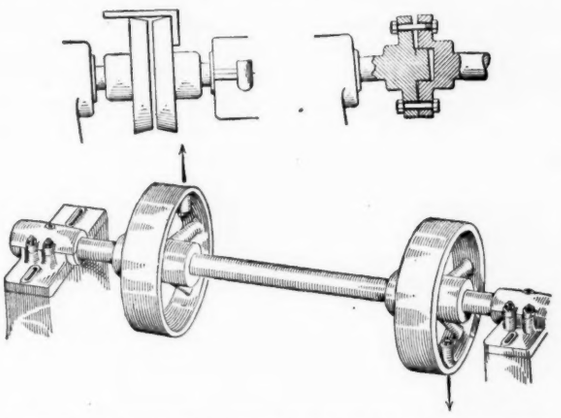


FIG. 2—STATIC BALANCE IN PULLEYS PRODUCES DYNAMIC UNBALANCE

couplings, which should be equally distant at all points of their circumference. It is possible that an apparent error may be shown if the faces of the couplings are not turned perfectly true; this may be checked by gaging the distance always at the same point on the couplings while both of the shafts are rotated; if this method is pursued, it is necessary to guard against end play by keeping the couplings separated as far as the bearings will permit at all times. Take readings at top, one side, bottom, opposite side and then the top, rotating in the same direction through each quarter turn.

A minute chip between the faces, a slight burr about a bolt hole, a slight scratch or scar on the face of either section, often caused by driving a cold chisel between the flanges, or drawing one bolt up tight while others are still loose, may produce an effect similar to that illustrated in Fig. 2, causing the flanges to be inclined, as in a shaft that is slightly sprung. The two halves should always be marked so that they will be reassembled with the same point opposite each other. The rigid coupling frequently allows the use of three bearings in a set instead of four; when connecting a four-bearing set, the two bearings next to the coupling must be very accurately adjusted to avoid unequal distribution of rotor weight. These couplings are usually of the plug and recess type.

Trouble arising from poor workmanship or assembling of the rigid coupling is frequently difficult to locate. The former may be detected by placing the shaft in a lathe and resurfacing the coupling if necessary; the latter by careful inspection. Incorrect alignment of the bearings may be detected by loosening the bolts in the coupling, separating the two parts slightly and using a feeler gage in the manner already described for a flexible coupling. It is usually advisable to place a support under the shaft on the side of the coupling farthest from the bearing, so that the weight of the apparatus will not be thrown on the loose coupling. If the bolts are a tight fit, it may be well to remove them entirely so as to allow freedom for the two parts to move if the bearings are out of line.

Check Unbalance by Running Uncoupled

Before attempting to adjust the balance, the engineer should be absolutely certain that the trouble is not in the alignment or the coupling; there is no surer way to get into trouble than to attempt to balance a set that does not need balancing. Vibration that occurs only when carrying a load or that increases with the load, is a pretty sure indication of trouble in the coupling or alignment. In a few cases it will be found that a set runs smoothly while cool, but begins vibrating as it warms up, which indicates that expansion due to temperature has produced a change, not in the balance, but in alignment. It is possible that a long shaft may become slightly sprung when subjected to a change in temperature, for which the only apparent remedy is a new shaft, although conditions may be slightly improved by changing the balance. It is generally possible and advisable to disconnect the driving member and run it alone; if it runs smoothly, that half at least is in balance. If the driven member is a generator, it may be possible to run it as a motor, at rated speed; if it also shows balance, the trouble must lie in alignment or coupling.

In the case of a very short rotating element, as the runner of a single-stage turbine, a careful adjustment of static balance will generally insure running balance also. Static balance is readily obtained by supporting the shaft on smooth horizontal steel rails and weighting the runner in such manner as will neutralize any tendency for the shaft to roll. A lathe bed answers admirably for this purpose if available. With a longer rotor, such as a generator armature or multi-stage turbine, this procedure is of little use, for although lack of static balance is a sure indication that it will vibrate in service, perfect static balance is no indication that it will not vibrate. As an exaggerated example take the shaft illustrated in Fig. 2, which carries two pulleys, one near each bearing, with the one on the left badly out of balance on account of the weight shown at the top. With the shaft rotating at a high speed, there will naturally be violent vibration in the adjacent bearing, with comparatively slight vibration in the distant one, the pulley there being assumed as perfectly balanced. If this shaft is laid upon rails, the lack of balance will be readily detected and the addition of a similar weight on the other pulley at the bottom will cause the shaft to balance perfectly, *on the rails*. If this combination is now run in its bearings, the vibration in the original bearing will remain practically unchanged, being effected by the adjacent wheel only, while there will be an equally severe vibration in the bearing at the right on account of the weight added at the bottom. The mere fact of shortening the shaft and substituting an armature of considerable length for the two pulleys does not alter the principle. It will also be noted that while the weight at the left is tending to throw its bearing in the direction indicated by the arrow, the other weight will tend to throw its bearing in the opposite direction.

Adjusting Balance

In applying this principle to a direct-connected set, all bearings should be loosened slightly, if the construction permits, in order to allow greater freedom for vibration of the shaft. A piece of chalk, or for more accurate work a scriver, should be brought up to the running shaft near each bearing until it just leaves a mark on one side of the shaft, thus indicating the direction of throw. Beginning with the bearing where the vibration is worst balance weights should be added to the rotor at the end nearest the bearing and on the side opposite the mark on the shaft. The result obtained should be noted by a new running trial; if the operation is so improved that the original bearing no longer shows the worst vibration, it is best to make the next balancing attempt on the one that does, rather than to attempt perfection on the first when it is likely to be thrown out in balancing the other. Many adjustments of this nature may be necessary before the desired result is obtained, but patience and a moderate amount of good judgment will eventually win out. Where flexible types of shaft or very high speeds are employed, marking the shaft is usually less satisfactory than using personal judgment as to which of several trials gives the best operation. By keeping a records of "shots" and their results, the true balance will eventually be determined. It is not advisable to drill holes for fastening balance weights in high-speed apparatus without first asking the manufacturer if weakening of the structure will be undesirable.

The mechanic sent out from the maker's factory has probably balanced a considerable number of machines of the same type as the one in question and naturally has a considerable advantage over one lacking such experience; he should be able to make a better guess as to how much weight to add between trials; he may be familiar with certain idiosyncracies of the machine; he is perhaps less likely to make errors and so can go ahead with greater confidence—all of which merely tends to shorten the time required to reach the desired end, which may be long at the best. There is, however, no reason why any mechanic of fair intelligence and moderate ability cannot produce equally good results in the end.

Brine Circulation with Centrifugal Pumps

By Russell K. Annis

In many refrigeration plants, especially in the smaller ones, no one seems to care how a centrifugal pump performs so long as the brine is kept in motion and the desired refrigeration effect is obtained. But in plants where the highest efficiency is desired and every detail, including the rate of brine circulation, is maintained at its most efficient point, it is necessary that the designer, operator and all concerned have a definite idea of the effect on a centrifugal pump when liquids heavier than water are handled.

Effect of Specific Gravity on Pressure Head

The calculation of the pressure required is often confusing. Referring to Fig. 1, two standpipes are represented as filled to a point 100 ft. above the center of the gages. One pipe is filled with water whose specific gravity is 1.00, and the other is filled with brine having a specific gravity of 1.20. It must be kept in mind that while both gages have a head of 100 ft., one has 100 ft. of water and the other has 100 ft. of brine. Too often this distinction is not made as to head where liquids heavier than water are used. If expressed in pounds per square inch, the gage having water head will read 43 lb., the equivalent of 100 ft. of water, and the gage having the brine head will read $43 \times 1.20 = 51.6$ lb. It will be noticed at once that to neglect this correction causes considerable error; in fact, cases have been known where it caused complete failure of the pump to deliver any brine at all. The rule for vertical head is, multiply the vertical lift in feet by 0.43, and then multiply this by the specific gravity of the liquid. This gives the pressure in pounds per square inch.

This is not the total pressure, however. In fact, in a closed system the vertical lift has no effect, since the riser-pipe head is balanced by the head on the drop, or

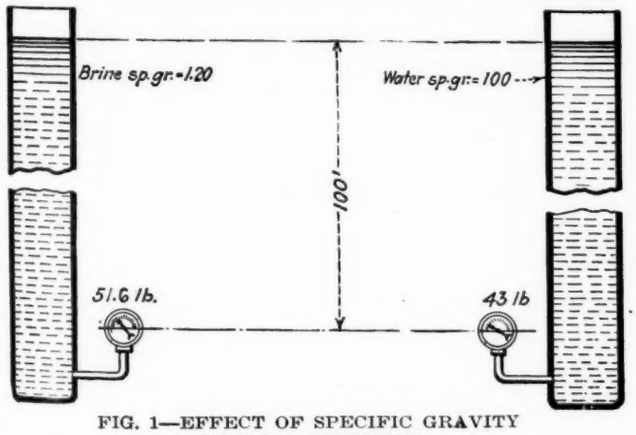


FIG. 1—EFFECT OF SPECIFIC GRAVITY ON HEAD PRESSURE

return pipe. Another item, the pressure required to overcome friction, is often subject to misunderstanding. This is usually obtained from friction tables, which are to be found in almost any engineer's handbook or pump manufacturer's catalog. If the friction table reads in pounds per square inch, there will be no difficulty. On the other hand, friction tables more commonly are in terms of head loss, and this means water head. To convert this to pounds per square inch, multiply the head in feet of water by 0.43, making no correction for specific gravity. This is an important point. The mistake is often made of multiplying by the specific gravity for friction loss. The reason this correction should be omitted is that the friction of brine in a pipe is not affected by its specific gravity but by its viscosity. As the viscosity of brine is approximately the same as that of water, the friction can be considered the same, if expressed in pounds per square inch.

It is very important to express both the vertical or "static" head, and the friction head in pounds per

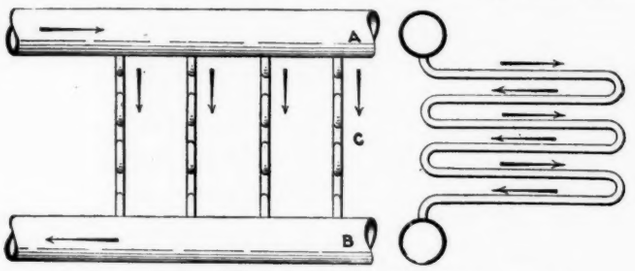


FIG. 2—BRINE CIRCULATION THROUGH COILS

square inch. For one thing, they must both be expressed in the same units, so that they may be added together to get total working head. Total working head could be expressed in feet provided the liquid being pumped were specified. However, this usually leads to complications, and it is always better to keep in terms of pounds per square inch except where pure water is being pumped.

The expression has been used, "Friction of brine in terms of feet of water." This is a very confusing expression and should be avoided by converting to pressure as soon as it is determined from the friction tables. It is because of this confusion and because of the necessity of getting all pressures in terms of the same units before adding that it is preferable to use pounds per square inch.

Frictional Resistance of Brine

Where brine is circulated through coils connected into headers as shown in Fig. 2, the friction in the various coils should not be added together. The proper method is to divide the total rate of brine circulation by the number of coils. This gives the rate through any one coil, and the friction should be figured on this rate. The length of pipe is the length of one coil and not the sum of all the coils. For example, four coils are shown in Fig. 2, and one-fourth of the brine passes through the coil *C*. This causes the pressure in *A* to be higher than the pressure in *B* by an amount equal to the friction in *C*, which conveys one-fourth of the total circulation. Each of the other coils produces a similar effect, but the results should not be added because they act in parallel.

The performance of a centrifugal pump is different where brine is being handled from what it is with water. This difference is accounted for by the fact that a centrifugal pump will deliver a liquid against a certain head when run at a stated speed, and this head refers to the vertical distance that the pump will discharge, no matter what liquid it contains. If it contains water, it will deliver the water, say, 100 feet, and a gage at the pump will read 43 lb. as in Fig. 3. If it contains brine having a specific gravity of 1.20, it will

pump the brine 100 ft., also, but the pressure at the pump will be 51.6 lb. This shows that to order a pump for a certain pressure without expressing the specific gravity, may cause a serious error.

It is commonly known that more horsepower is required to pump brine than to pump water. This is true, however, only where the vertical lifts are equal. In that case the pressures will be different, as just explained, and the greater horsepower will be required for the greater pressure. Pumping brine against a given pressure requires no more horsepower than pumping an equal rate of water against the same pressure. This is another good reason for using pounds per square inch and not feet of head. Once the allowance is made for specific gravity, it does not enter again into the calculation.

Handling Brine With Water Pump

The question sometimes arises as to what will be the effect of taking a pump originally intended for water service and using it for brine circulation. This is a thing that cannot be determined precisely without knowing the characteristic of the pump, but if the rate of discharge (gallons per minute) is not changed greatly, the pressure will be increased approximately 20 per cent and the horsepower will be in proportion to this increased pressure.

As an illustration of the effect of brine on the performance of a centrifugal pump, the writer has actually

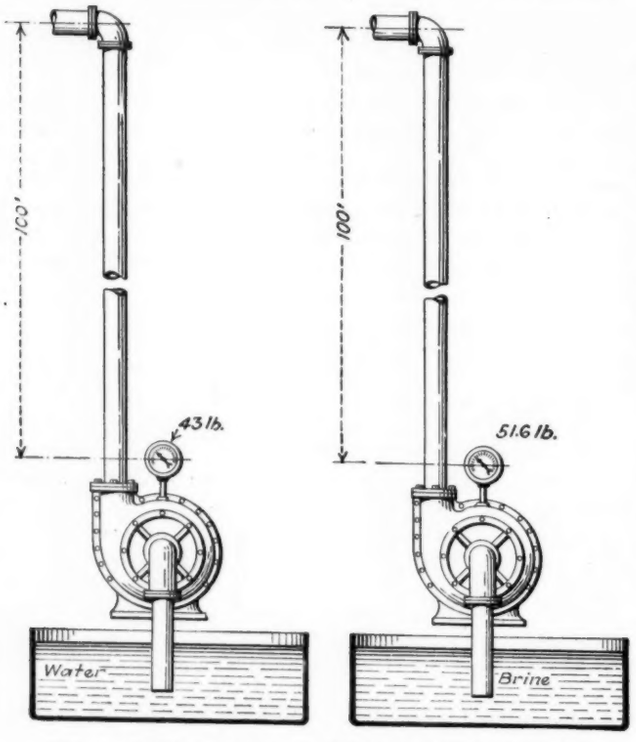


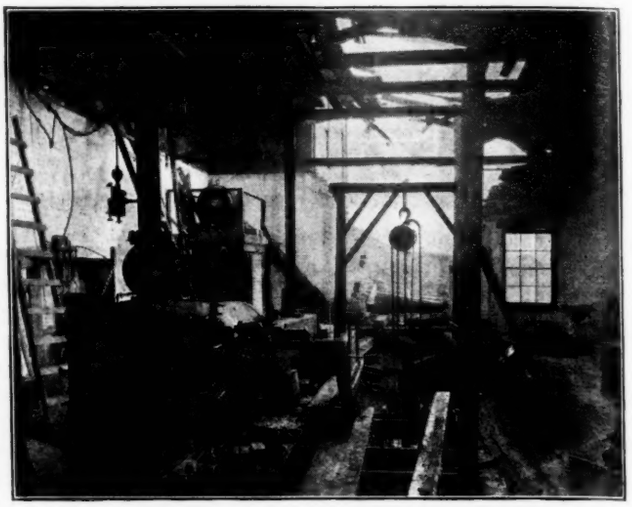
FIG. 3—HEAD PRESSURE ON CENTRIFUGAL PUMP

set up a small pump with a pressure gage in the discharge line. Water was pumped from a barrel and returned to the barrel through a throttle valve. The valve was closed to a point where the gage read 20 lb. Salt was shoveled into the barrel, and the pressure rose to almost the theoretical 24 lb., but the additional horsepower caused the motor to fall off in speed slightly. Where a low-head lightly constructed pump is used the extra pressure might fracture the casing.

Flywheel Explosion at Seguin, Texas

A sixteen-foot flywheel exploded in the plant of the Fraser Brick & Tile Co., Seguin, Tex., Feb. 16, with heavy damage to the engine, but fortunately with no loss of life.

The engine, a Corliss 20x42 in., running at 100 r.p.m., was belted to a 300-kw. 480-volt a.c. generator. The trouble started when the generator belt broke and



ENGINE ROOM AFTER EXPLOSION

catching on a roof truss, brought the latter down on the governor. This put the governor out of action, allowing the engine to run away.

The flywheel, which had eight arms, was cast in halves and was bolted at each rim joint with six bolts. The rim and one spoke broke away, leaving the other seven spokes and hub on the shaft. Pieces of the rim of various sizes were thrown high in the air, and one piece about seven feet in length was thrown to the east of the plant and passing over the company office and a high kiln, buried itself nearly out of sight in the store yard some 350 ft. from the engine room. Another large section came to rest upstairs in the tile drying house 75 ft. from the engine.

The cylinder and engine bed were not damaged, but the crankshaft was slightly sprung. It is thought that the shaft can be saved by truing up in the lathe. The governor was demolished and some of the lighter parts of the valve gear were knocked off. The outboard bearing pedestal bolts were stretched and bent to some extent and the pulley on the generator was knocked off.

When the British Coal Conservation Committee made its report in 1917, it strongly recommended the replacement of the smaller central stations by a system of interconnected superpower stations. The idea was received at the time with enthusiasm, but up to the present very little has been done in this direction; the British, according to the *Engineer*, apparently consider splitting up their power supply into a number of smaller units as a greater insurance against interruption of service. At a recent joint meeting of the Institutes of Mechanical, Civil and Electrical Engineers at Birmingham some skepticism was shown regarding the superpower idea, the opinion being expressed that it is not only the saving in coal, but the cost to the ultimate consumer, that must be considered.

Mean Effective Pressures of Internal-Combustion Engines

By ROBERTSON MATTHEWS

IN CHECKING results of tests on internal-combustion engines with the theoretical possibilities a large amount of computation must ordinarily be made. This often deters one from going very far into the matter. To make the work of computing the theoretical mean effective pressure, air to fuel ratio, etc., the chart shown in the illustration has been prepared. By its use, given the desired theoretical mean effective pressure and the suction pressure and temperature, the pounds of air required per pound of fuel is found directly.

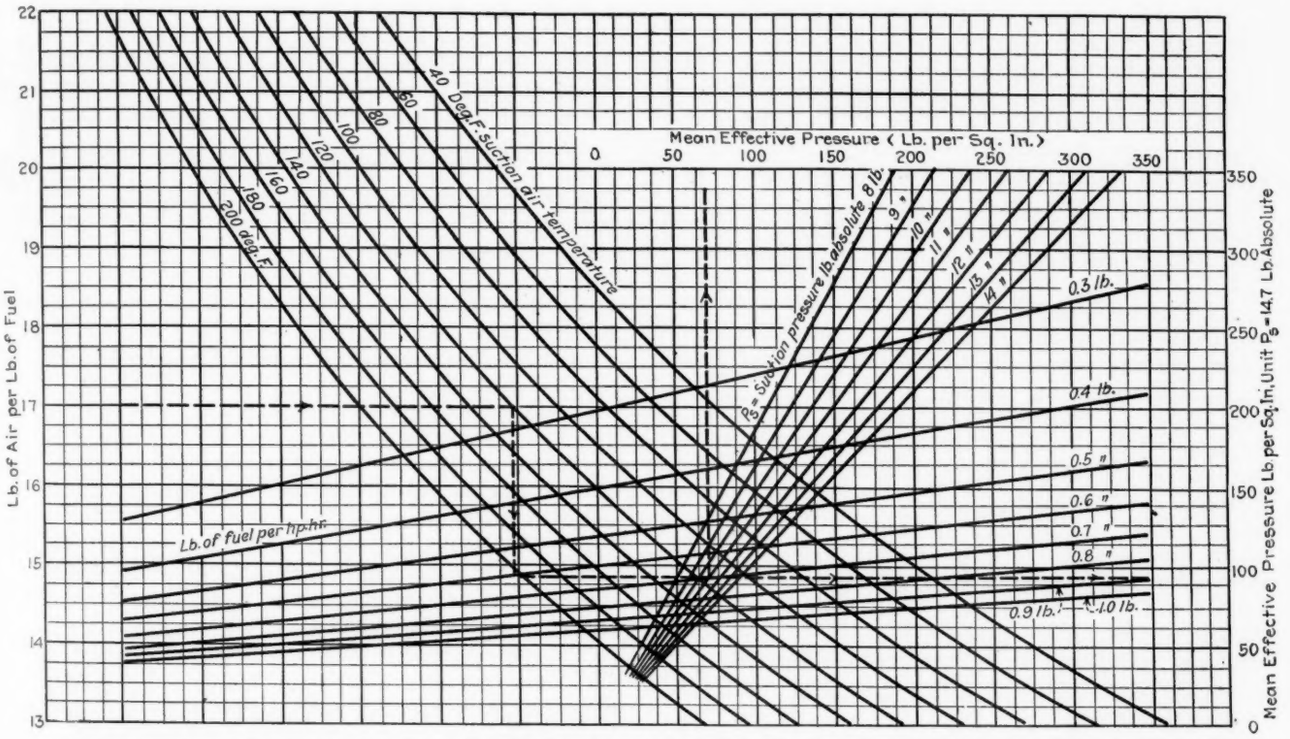


CHART SHOWS RELATION OF AIR TEMPERATURE, AIR-TO-OIL RATIO, AIR-SUCTION PRESSURE AND M.E.P.

The conditions affecting the power capacity of an engine cylinder because of their effect upon or their relation to the cylinder's air (or oxygen) capacity may be listed as follows: (*a*) Temperature of air at beginning of compression; (*b*) pressure of air at beginning of compression; (*c*) pounds of air supplied per pound of fuel; (*d*) pounds of fuel supplied per horsepower-hour, which represents the thermal efficiency for a fuel of given heat value; (*e*) density or molecular weight of the fuel.

The conditions determining the temperature and pressure at the beginning of compression vary more with carburetor than with injection engines because of the influence of fuel evaporation. The curves of the diagram take into account the effect of volumetric efficiency in so far as temperature and pressure of the air charge are concerned, but the influence of detonation is, of course, beyond estimate.

Item *c* affects the mean effective pressure since the greater the amount of air supplied per pound of fuel the less the possible elevation in temperature and pressure of the gases upon combustion.

Item *d*, when items *a*, *b* and *c* are fixed, influences the engine's capacity, since the greater the weight of fuel required per horsepower-hour the greater must be the weight of the mixture taken in by a carburetor engine, or the greater the weight of air in the case of a Diesel or semi-Diesel engine. Hence the required piston displacement depends upon item *d* as well as on *a*, *b* and *c*.

Respecting item *e* there are two conditions associated with an increase in density of the fuel charge that must be considered. It is characteristic of hydrocarbon fuels that as their specific gravity increases, the weight of excess air required per pound of fuel to give efficient combustion in an engine also increases. This is a condition which the number of heat units per unit volume of chemically correct mixture does not reveal. For this reason the heavy-oil engine will require a greater weight of air per pound of fuel than will the carburetor engine.

The greater the specific gravity of a hydrocarbon fuel the higher, as a rule, is its boiling point, and as a consequence, the warmer the air must be to give complete evaporation of the fuel. With heavy fuel the initial pressure and temperature in a carburetor-type engine must be higher than when light volatile fuels are used.

The use of the chart may be illustrated by an example. The truth of the values obtained from the chart depends upon the selection of a set of conditions that are consistent with actual operation. Take, for example, the conditions indicated on the diagram by the broken lines, which are as follows: Pounds of air per pound of fuel, 17; temperature of air at beginning of compression, 120 deg. F.; pounds of fuel per horsepower-hour, 0.6; air pressure in cylinder at beginning of compression, 11 lb. per sq.in. absolute.

How to Find the M. E. P.

Beginning at 17 lb. on the left-hand scale, move across to the right to an intersection with the 120 deg. suction air line. Then drop down to the 0.6 lb. fuel line and move across to the right again. If the pressure at the beginning of compression were 14.7 lb. per sq.in. absolute, the scale on the right would give the attainable mean effective pressure as 93 lb. Since the pressure at the beginning of compression is given as 11 lb. instead of 14.7 lb., we must stop in movement to the right at the intersection with the 11 lb. line. The attainable mean effective pressure is then read from the scale at the top and for the conditions given is 70 lb. per sq.in. absolute.

But is this indicated mean effective pressure or brake mean effective pressure? If the fuel consumption is stated in terms of indicated horsepower-hour, then the mean effective pressure read on the scale is indicated mean effective pressure; if stated for brake horsepower-hour then the mean effective pressure found by the chart is brake mean effective pressure.

To illustrate the effect of a high air temperature, let the problem be the same, but with the air temperature 200 instead of 120 deg. F. Beginning at 17 lb. on the left-hand scale continue across to the right to the intersection with the 200-deg. line. Then drop down to the 0.6 lb. line and move to the right to the 11 lb. line. Moving up to the mean-effective-pressure scale at the top, the answer is found to be 62 lb. per sq.in. Hence a change in the initial temperature of the air charge from 120 to 200 deg. F. at the beginning of compression causes the mean effective pressure to drop from 70 to 62 lb. absolute.

The chart readily shows the weight of air that can be used per pound of fuel when an indicated mean effective pressure of a definite value is desired. As example, assume that the desired indicated mean effective pressure is 75 lb. with a suction air pressure of 13 lb. absolute and an air temperature of 140 deg. F. The fuel consumption is to be 0.5 lb. per indicated-horsepower.

Determining Weight of Air Required

Beginning at 75 lb. on the mean-effective-pressure scale, drop down to the 13-lb. suction-pressure line. The pencil is then moved to the left to the 0.5 lb. fuel-per-hp.-hr. line, and up to the 140-deg. air-suction temperature line, and on the scale at the left opposite this intersection the answer is found to be between 21.75 and 22 (21.9 to be exact) lb. of air per lb. of fuel. This corresponds to about 40 per cent excess air.

It will be noticed that for any air temperature less than 140 deg. F. more than 22 pounds of air per pound of fuel could be allowed. Looked at from another angle, if the air temperature were more than 140 deg. F., less than 22 pounds of air per pound of fuel could be used, since the intersection would come opposite to some point below 22 on the left-hand scale. The 21.92 lb. of air read from the chart is the weight of air at 13 lb. absolute pressure and with a temperature of 140 deg. F. required per pound of fuel to satisfy the conditions laid down. The volume of air at 13 lb. and 140 deg. F. that the engine would have to take in per indicated-horsepower would be the volume corresponding to 21.92 lb. of air $\times$ 0.5 lb. of fuel.

Assume that we have a desired brake mean effective pressure of 100 lb., an air pressure at the beginning of compression of 14 lb. and an allowance of 18 lb. of air per pound of fuel at 100 deg. F., what fuel consumption would be necessary per brake-horsepower-hour?

Drop down from 100 lb. on the upper mean-effective-pressure scale to the intersection with the 14-lb. line. Hold on to this intersection. Now move from 18 lb. on the left-hand scale to the intersection with the 100-deg. F. line. Drop down from this intersection and at the same time move to the left from the intersection being held on the 14-lb. line. This gives an intersection just below the 0.5 line of fuel consumption; or about 0.51 lb. of fuel will be required per brake-horsepower.

Chart Compared with Test Results

A study of the chart leads one to ask what the *maximum* attainable mean effective pressure might be. This the chart cannot show because of the many conditions that control the fuel economy. Some practical examples are, however, of interest. In the report on certain English tests mention was made of a 20-in. cylinder giving 150 lb. mean effective pressure. Evidently, this was indicated mean effective pressure. In the operation of small high-speed engines, aviation engines for example, at 1,600 to 2,200 r.p.m., brake mean effective pressures are obtained ranging from 110 to 135 lb. In a small engine by the addition of some cooled exhaust gases, a brake mean effective pressure of 140 lb. was obtained. Could the mean effective pressure of these high-speed engines and the economy of large solid-injection engines be combined, some remarkable results, the chart shows, could be shown.

The fuel economies for aviation engines range around 0.5 lb. per b.hp.-hour, being commonly on the upper side. Economies for large solid-injection engines are stated to be under 0.4 lb., the lowest probably on record being 0.385 lb. per b.hp.-hour. Now turning to the chart and taking the following values (which taken together are consistent for an aviation engine)—air temperature, 120 deg. F.; air pressure, 14 lb.; pounds of air per pound of fuel, 15.5; fuel economy, 0.5 per b.hp.-hour—the brake mean effective pressure from the chart is 116 lb. With other conditions unaltered, a change in economy to 0.4 lb. would, the chart shows, give a brake mean effective pressure of 145 pounds.

On account of the great probability of a wide variation in the composition of any seam of coal, the proper sampling, both of coal and of coke produced from it, is of extraordinary importance and is obtainable with more or less difficulty. To secure a representative sample of any body of coal or coke, due consideration must be given to the number and location of the points from which the different portions of the sample are collected and the relative sizes of these portions, while next in importance is the manner in which the operations of crushing, quartering and pulverizing the sample are carried out.—*U. S. Steel Handbook on Sampling and Analyzing Fuels.*

"Exorcising a Jinx"

By D. F. Nisbet

In the middle sixties, and even later, the steam-engine indicator was still considered by the steam-engineering laity as a scientific novelty rather than a practical instrument, designed for informative researches into the action of the steam in the engine cylinder and for determining the power developed under the various conditions of service.

The old McNaught indicator and possibly also the then new Richards instrument were in limited use, principally by U. S. Naval Engineers. At that period there were few if any publications describing the theory or practice of steam engineering, in the comprehensive manner we now have them, therefore the indicator and its uses, naturally, were little known.

Stethoscope in General Use

About the only instrument of "precision" in general use in those days was a "stethoscope" composed of a long lead pencil or a pine stick, held in the teeth, with ears stopped, and applied to various parts of the cylinder and steam chest to determine by sound if any abnormalities within could be distinguished. And it was surprising how expert some of the old-timers became in identifying the internal disorders of an engine with this simple instrument.

The engine, the erratic performance of which this is a chronicle, was in the basement of a three-story machine shop erected on the sloping bank of a river. The basement walls at the front were built in an excavation in the bank, while at the rear or river side the basement floor, which was also the engine-room floor, was about three feet above a bench on the river bank. This bench, some ten to twelve feed wide, extended downstream about 200 ft. to a bend in the river.

The engine was a plain slide-valve machine of the usual type of that period, controlled by a throttling governor. The cylinder, as I recall was about 20 in. in diameter by 36 in. stroke. The steam chest was at the side, with the exhaust connected at the bottom, the pipe passing downward underneath the floor and thence outward through the foundation wall. Originally, the exhaust pipe terminated at this point, but later two elbows and a short length of vertical pipe were added and connected to a line of 12-in. cast-iron pipe laid in a trench excavated in the bench mentioned, the pipe extending downstream to within a few feet of the end of the bench. The pipe was covered except at its termination, where there was an open ditch to the river.

One Monday morning the engine was started at the usual time and ran as smoothly as could be desired for about three hours, after which it began to slow down whenever any of the larger machines were started, recovering but slightly when they were cut out. Finally, when the "large" planer in the wood shop was started, the engine "lay down" definitely.

The engine was shut down and a hurried examination made to ascertain if any bearings on the engine or lineshafts were heating or "seizing," also the boiler pressure was increased to the blowing off point, as a test of the accuracy of the steam gage, but the results did not afford any satisfactory explanation of the cause of the trouble. The "stethoscope" had been applied, of course, but it simply disclosed an apparent overloading and did not furnish any evidence at to the cause; whereas, an indicator, had such an instrument been available, would have given an immediate clue to the abiding place of the troublesome "jinx."

The engine was again started and ran normally for an hour or so, and then the "jinx" was again in evidence. We dragged along, alternately starting and stopping machines, until the noon shutdown, when the superintendent detailed men to examine the piston rings, inspect the valve setting and verify the reference lines on the eccentric and shaft, but no cause for the trouble was found. A new steam gage was installed during the noon hour, on the assumption that both it and the safety valve were giving perverted evidence.

Shortly after one o'clock the engine was started and, as in the early morning hours, was apparently in a good operating condition. In the meantime the foundry foreman had fired his cupola, and at about two o'clock cut in his blower. By three o'clock the "jinx" again made itself manifest, and to forestall a "mess" in the cupola, all departments other than the foundry were closed and the men sent home excepting a crew from the machine shop, who were detailed to work on the engine as soon as the heat was poured off. The engine, with only the blower and lineshafts, "carried on" quite easily.

When the heat in the foundry was completed, the fires under the boilers were drawn and the machinist crew practically dismantled the engine, taking out the piston and slide valve, taking down the stop valve and governor, also the steam pipe from the boiler; and as soon as the steam was sufficiently low, the boiler valve was removed. In fact, every part was thoroughly examined for possible obstructions. It was found that the boiler valve would not open fully because of a bruised thread and that the governor valve was loose on its spindle and did not give a full opening when the balls were down; but aside from these minor defects nothing was found that even remotely suggested a lurking place for the "jinx." Therefore, the superintendent reluctantly ordered the parts re-assembled.

Discovery of the Jinx

The following morning we had a repetition of the trouble, and at about ten o'clock, the superintendent, in disgust, gave orders to close the works and for all employees excepting those whom he chose to assist him, to report again at one o'clock.

A few of us who lived so far from the shop that it was not worth while to go home and come back, went out on "the bench" to pass away the time. A couple of apprentice boys followed us out and they wandered down to the end of the bench, where the exhaust pipe terminated. They presently hailed us, pointing to the ditch. Out of curiosity, we went down, and immediately sent word back to the engine room asking the superintendent to come down, which he did after some hesitation.

What he saw was a discarded bottom board for a molder's flask, over the end of the exhaust pipe, held in place by stones piled against it, with numerous streams of water spurting out around the flange and through the interstices in the board. He ordered us to remove the obstructions from the end of the pipe and, first, there came a dead cat, which had evidently taken refuge in the pipe and been imprisoned there by mischievious boys on the previous Sunday, and then several hundred gallons of water. Then the superintendent went back to the engine room.

Boiler Inspecting—IV

By James F. Hobart

THIS article, the fourth of the series, points out some of the troubles frequently found when inspecting the rear part of the boiler.

AFTER the boiler firebox and shell-plates have been looked over, the inspector will slide over the bridge wall into what is usually known as the "back combustion chamber," and carefully examine the boiler shell in that section. Scrape each joint with the hammer-peen and note every sign of leakage or wasting. There is seldom any bulge found back of the bridge wall, but corrosion is more likely to take place at this part of the boiler.

The best-set boilers are suspended, but most shells are placed upon metal plates, in turn laid upon the brick side walls. Look carefully at the brickwork, both inside and outside the setting, below the rear lugs. The lugs and plates should have metal rolls between them, as shown in Fig. 1, and be free to move past one another as the boiler shell expands and contracts.

The boiler should be anchored at the front end where there are no rollers between the plates and lugs and the shell is more or less firmly held by the brickwork. Thus the movement caused by expansion should take place at the rear end of the boiler. See that the plates and rolls are working properly. Sometimes they get caught, and expansion of the boiler cracks the brickwork and may eventually break it down, if not seen and remedied in time.

The inspector should give special attention to the blowoff pipe and its connection to the boiler. The usual connection is a flange riveted to the bottom of the boiler

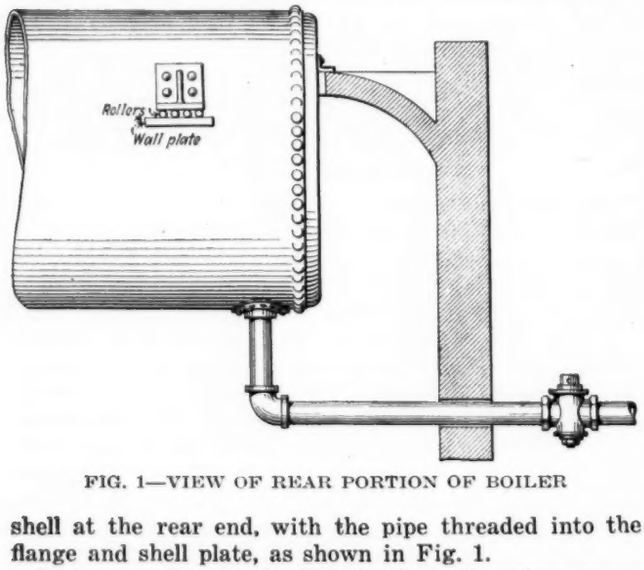


FIG. 1—VIEW OF REAR PORTION OF BOILER

shell at the rear end, with the pipe threaded into the flange and shell plate, as shown in Fig. 1.

Leaks are frequently found where the pipe screws into the flange, and also between the flange and the boiler, with leakage deposit piled up around the edges of the flange. Where leaks of this nature are found, there is usually a cause for them which may often be traced by the inspector to an improperly placed blowoff pipe; or perhaps the pipe may be anchored solidly in the wall and is therefore unable to move back and forth as the boiler expands and contracts, with the result that stresses are set up in the pipe, which may tear loose the pipe in the flange or even loosen the flange from the boiler.

Sometimes the inspector will find a wasting away of the flange, and in some instances the flange is so eaten away that it cannot hold the pipe tightly, and leakage results.

Blowoff Pipe Protection

Many different methods of protecting the blowoff pipe and its flange from the direct heat of the gases have been tried with varying success. Placing a larger metal pipe around the blowoff does protect that pipe

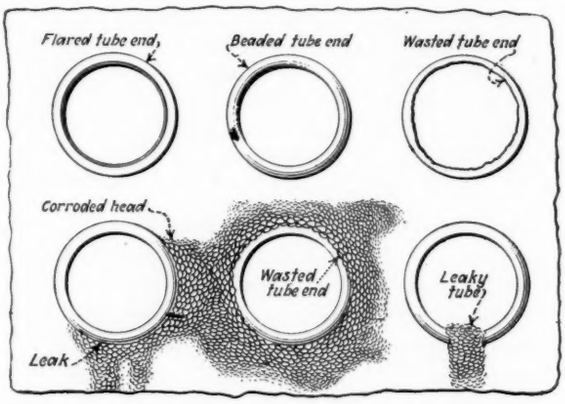


FIG. 2—SOME TUBE-SHEET TROUBLES

for a time, but this eventually burns away, leaving the blowoff pipe exposed again to the direct heat of the flame.

Attempts have also been made to protect the blowoff pipe by brickwork. Where this is done it must not be built solid against the blowoff pipe or it will prevent free movement of the pipe. Neither must the brickwork be permitted to touch the boiler shell.

The inspector should examine the methods used to protect the blowoff pipe and make sure that they do not interfere with the free movement of the blowoff pipe or the rear end of the boiler. Furthermore, the size of the blowoff pipe and the kind of valve or cock used therewith, must be determined and entered upon the data sheet, as also must the disposition of the end of the blowoff pipe, which should never be hidden. It is always better—and some inspection laws require—that the end of the blowoff pipe be so located that leakage may be seen at all times.

When the blowoff discharge is hidden in a sewer or some other out-of-the-way place, there is great danger of loss of water through the blowoff, and instances are on record where accident has been caused by an almost complete loss of water from the boiler. See also that the blowoff pipe is properly supported in such a manner that when the blowoff cock is opened, the pipe will not be loosened or perhaps torn from the boiler.

Inspecting the Back Arch and the Back Head

When inspecting this arch, see first that it is built low enough so that the water level inside the boiler can never fall below that of the arch, which, if placed too high, will leave a section of the tube sheet bare when the water chanees to be low in the boiler. The back arch then, should be placed just high enough to clear the top row of tubes.

See also that the arch does not touch the boiler and that there is room enough for the boiler to expand to the limit without touching or binding against the arch. See that dirt and bits of brick have not fallen in and

lodged between the boiler-head and the arch. Something will be pushed out of place if this space gets filled up. It is advisable to have this gap covered by a plate which moves with the boiler and slides over the arch and prevents air from entering the boiler setting.

Look closely to the joint or seam between the shell and the rear head of the boiler, especially at the bottom. The back head is more likely to be affected by corrosion than is the front head.

There are many kinds of trouble to be looked for at the back head. Use the hammer freely when looking it over. Cut down into any deposits of dried-on dirt and chemical salts, cut through them and thus determine if the deposit is merely on top of the plate or whether it is the result of deep corrosion into the tube sheet. The inspector should give careful attention to these parts of the boiler. The metal around the heads of the lower rivets is sometimes eaten away until the rivets seem to be standing upon little islands. Sometimes the rivets too, are found badly corroded.

Flared and Beaded Tube Ends

Both methods of finishing tube ends are shown in Fig. 2, and the inspector may find one end of the tubes all finished by one of these methods, while all the tubes at the other end of the boiler are finished the other way.

Watch for wasted tube ends, for sometimes these have been found in a dangerous condition. The illustration shows a tube that has become worn or wasted until thin and without sufficient thickness of metal to hold to the head properly.

Look out for leaky tubes, both those that leak around the outside of the tube and those with a leak inside. When the leakage is bad, the inspector may find a stream of water running out between a tube and head, but more often there will be found, as shown in the lower left corner of Fig. 2, merely a lot of dried-on dirt, corrosion salts and other substances below the tube, left there from a former leak which has perhaps opened and closed several times and at the time of inspection is not leaking. In such instance the inspector will report "signs of leakage" against the tubes where such indications are to be found.

Corroded Boiler Heads

There is a peculiar form of corrosion which seems to attack the rear heads of boilers more frequently than any other part. Many boilers are free from it, while with others it seems impossible to prevent it. Fig. 2 shows about how such corrosion is likely to be found. It usually starts between a pair of tubes and spreads all around one or more of them and sometimes covers a large part or even the whole of the boilerhead.

It is the inspector's duty to discover and report all cases of this kind and also to determine the probable depth to which the corrosion has penetrated the plate. Sometimes the depth may be determined by the use of the long and short scales as for measuring the wasting away of plate edges at joints. But when the corrosion has attacked the whole or a large part of a tube-sheet, either remove a tube or two that the thickness of the plate may be measured, or drill one or more holes through the corroded part for the same purpose. The holes can be later tapped and plugged with a standard pipe plug.

When not allowed to drill a corroded head, the inspector can only report accordingly, but he is likely to make it less than the actual thickness and the working pressure of the boiler may have to be reduced considerably. In many cases there is no remedy for tube-sheet corrosion, save the putting in of a new head, and strange to say, in some cases the new head may be found free from further corrosion in spite of the fact that corrosion of the replaced head could not be prevented even by frequent and thorough cleaning and the application of red-lead paint to the plate. Conditions that give rise to electrolytic action between adjacent plates in some instances seem about the only reason for the persistent corrosion.

Early Experiments with Superheated Steam

By R. A. Holme*

In 1705, Denis Papin, the French physicist, made what was probably the first application of superheated steam. By placing a mass of heated metal in a recess on the steam side of the piston of Dr. Avery's engine, he reduced the condensation of the working steam and produced what was in effect a superheater.

A certain Captain MacGregor, built (at Cornwall, England, in 1828) a brick jacket around the cylinder and the steam pipe of his pumping engine. He left a space, or flue, between the brick and the metal and, by maintaining a fire in this space, reduced the steam consumption of his engine to a remarkable extent.

Until about 1870 engineers took great interest in superheated steam. Ericsson, Hirn and Isherwood conducted many experiments, securing excellent results. During this period most of the superheaters were installed in connection with marine boilers.

However, about this time vast improvements in the steam engine were introduced: namely, compounding, condensing, improved valve gear, and higher steam pressures. These improvements, together with the troubles encountered in stuffing boxes, gaskets and lubrication where superheated steam had been used, tended to limit its application for a number of years. In 1874 Dr. Kirk introduced the triple-expansion engine, and it soon became the standard type of marine engine. The steam pressure was still further increased and consequently the temperature, thus militating against superheating under the then existing conditions.

Hirn continued his experiments and, in a series of tests made in 1892, showed a saving in fuel of 20 per cent with the superheater installed within the boiler setting. He superheated the steam to from 86 to 113 deg. F. His successors, Schwoerer, Schroter and Schmidt, made rapid strides in again bringing superheating into use. In 1895 Schmidt built a boiler and engine for use with superheated steam, and Professor Schroter's tests showed that it developed an indicated horsepower upon 10.4 lb. of steam per hour, or about 1.3 lb. of coal. The steam pressure was 156 lb. and the superheat 189 deg.

This was a remarkable performance, especially as the engine was of only 75 hp. Soon after the reports of this and other tests were published, interest in superheating rapidly revived, especially in Europe. Lubricating oils, packings and gaskets were brought out which gave perfect satisfaction on superheated steam. During the last ten years pressures have been steadily increasing as has also the degree of superheat, resulting in higher final temperatures.

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Energy Source for Electric Automatic Engine Stops

By J. Elmer Housley

The use of automatic engine stops for the remote control of the stopping of a steam prime mover is necessary, and if the various stop stations are to be at all remote, electrical operation is essential. There are proponents for each of the various electrical systems that may be used. There are two principal systems for the electrical tripping of the quick-acting steam valve—the closed-circuit and the open-circuit.

The closed-circuit system is generally considered to have the advantage of greater reliability. A current flows continuously in the normally closed circuit, and a magnet coil holds the triphammer. As soon as a stop button is pushed or a wire in the circuit is accidentally opened, the magnet coil releases the triphammer, which drops by gravity and releases the self-closing steam valve. In the open-circuit systems energy is supplied to one side of the magnet coil and to one side of each normally open "stop" switch. On closing any one of these switches, the circuit is completed and energy is supplied to the magnet coil which attracts a trip mechanism, thereby releasing the self-closing steam valve on the unit it is desired to stop.

Constant Voltage Necessary

Having decided to use the closed-circuit system, a very important item remains for consideration—the source of energy for the system. A constant voltage must be maintained which is free from interruption, because any failure of power or even a 25 per cent decrease in potential will release the trip and stop all prime movers so equipped. Storage batteries are looked upon with favor for the source of energy for this system; however, experience in some plants, with the usual neglect of the batteries, indicates that the most desirable source of power is from a constant potential exciter bus equipped with ground detectors, so that any breakdown of insulation would not jeopardize both the excitation and the engine-stop systems.

One objection often made to this arrangement is that in case of failure of the excitation the prime movers would be shut down, but this objection is nullified to a degree by the fact that in the event of failure of the excitation the prime movers may overspeed and trip out regardless of the source of energy for the automatic stop. Experience has shown this method of energy supply to be most desirable.

Where voltage regulators control the exciter voltage, it becomes necessary to use storage batteries, as the fluctuations of exciter voltage would cause the magnet coil to release.

In order to test the stop systems and keep them limbered up, the prime movers should always be shut down, when taken out of service, by means of the automatic engine stop.

The ventilating ducts of air-cooled transformers can be blown out with compressed air at about 25 lb. per sq.in. This should be done every day or so, when they are installed where large quantities of dust are met with in the cooling air. Before using the compressed air, it is good practice to clean the air ducts and the outside of the windings and the core with a felt swab, taking care not to injure the insulation.

New Type of Generator Air Cooler Employs Condensate

Up until the last two or three years the cooling of large turbo-generators was accomplished by what may be called an open system of forced ventilation. Air was taken from outside the power house by fans on the generator's rotor or by separate fans and either passed through a filter or washed by passing through a water spray and forced through the generator windings and ventilating ducts in the cores and then discharged outside the power plant. Provisions were generally made for discharging all or part of the air inside the power house during the winter months and recirculating it through the generator. In this way the generator losses were used to heat the building. With this method a fresh supply of air is all the time being taken into the machine, and no matter how carefully it may be washed it will always contain a small amount of dirt. When it is considered that a large turbo-generator has passed through it about every forty minutes a volume of air equal to its own weight, it is realized that with even a very low percentage of dirt in the air a considerable weight is carried into the machine. Part of this lodges in the core air ducts and in time seriously interferes with the cooling of the machine. The dirt that lodges in the winding along with that in the ducts creates a fire hazard, as there are many serious examples to testify.

To prevent as far as practicable dirt from getting into the machine and to make possible better provisions for fighting a fire should one start in the winding, closed systems of ventilation have been adopted. The one first used in this country was that, where, after the air passed through the generator, it was taken through a water spray and cooled, then passed back through the generator again. This required that there be available a considerable volume of fairly clean water for cooling the air, and the heat losses from the generator windings are not recovered.

A second system of closed ventilation is one in which the air is cooled by passing over a radiator through which the cooling water circulates. With this system the air does not come in contact with the water, and the condensate can be used for cooling the air and a large percentage of the generator losses recovered in the feed water. Since the cooling water is the condensate, it is handled by the hotwell pump in the usual manner, the air cooler being connected between the hotwell pump and feedwater heater.

The first installation of this kind in this country has recently been made by the General Electric Co., on one of the generators of the Amsterdam plant of the Adirondack Power & Light Corp., Amsterdam, N. Y. The air cooler as installed with the machine consists of three sections, each having two cast-iron headers connected by 258 one-half inch brass tubes seven feet long, which give a total cooling surface of approximately 700 sq.ft. The cooling surface of the tubes has been increased by soldering spiral fins on their outside surface for their entire length. Tests made on the equipment show that the temperature of the condensate is increased 14 deg. F., when the ventilating air's temperature is reduced 50 deg. F., with the machine carrying full load. The cooler is located entirely between the foundation piers and takes a small amount of space that would not be used for anything else.

EDITORIALS

F. R. LOW, EDITOR

Feed-Water Treatment—A Field for Consulting Engineers

FEW things in power-plant operation are of more importance that the proper handling of the problems due to bad makeup water, and none requires more knowledge for its correct solution. Although scaling, priming and corrosion can almost invariably be cured, the number of cures is bewildering. It is hard for the average engineer to choose between so many different methods. Shall he feed chemicals directly to the boiler, or shall he install a chemical softening plant? If the latter, should it be a "hot" system or a "cold" system, and should it be of the continuous or the intermittent type? Will a zeolite softener be better fitted to his needs? Are his conditions such that the advantages of distilled makeup warrant the installation of evaporators? If so, should they be operated by live or exhaust steam, and how should they be fitted into the station?

These are fair questions. All these methods of treatment are in successful use today in various plants, and each has its field, but how is the engineer to determine which is the best for his particular conditions? Careful study may enable him to narrow the field down to three or four possibilities, but he can hardly make a wise choice among these without expert help.

While in general, the actual operation of the various systems is a relatively simple matter, the proper selection of equipment requires a greater knowledge of chemistry, heat balance, etc., than an engineer may reasonably be expected to possess.

Two courses are then open to him, to be followed either separately or in combination. One is to get in touch with the various manufacturers involved and ask for their recommendations. If he is careful to deal only with manufacturers who have established reputations for good products and fair dealing, he will doubtless arrive at a satisfactory solution of his difficulties and possibly at the one best solution.

It seems, however, that this is a field that could profitably be entered by more consulting engineers thoroughly acquainted with feed-water troubles and all the various methods of treatment. A consulting feed-water expert who had nothing to sell but his service and was able and willing to recommend any type of apparatus on the market that would best meet the particular needs of his client, should find his services in great demand.

Increased Land Values a Factor in Coal Cost

THE anthracite mine workers have filed with the Federal Coal Commission a further communication regarding the elements entering into the cost of anthracite to users. One of the principal charges made against the practices of the industry relates to the investment claimed for coal-land reserves in the anthracite region. The Commission is urged to determine the facts relating to the original investment in such lands, the increases in value attending transfer of property in this territory, and the present "inflation in the excess coal-land holdings."

The problem thus presented for the anthracite business is of equal or greater importance in the bituminous industry. Bituminous land values have increased tremendously, and these so-called "values" affect the price of coal to the user to a marked degree.

Within the last few weeks there has been a most striking example of such increasing costs of coal lands. This was developed in connection with the purchase of land and coal rights by the Bureau of Mines for the property on which the experimental mine of the Bureau is located. A brief history of that particular property shows one of the problems that confronts the American coal user today.

The land in question has been purchased with an appropriation of $75,000, just granted to the Bureau by Congress. Approximately $15,000 of the total has been used to purchase something over seventy-five acres of surface land. The balance was used to purchase approximately forty acres of coal at about $1,500 per acre. This latter figure represents a material concession to the Bureau below current prices asked for similar coal land in this immediate vicinity. Nevertheless, the $1,500 per acre now paid is twenty times the value per acre which is reported to have been placed on this identical property when it represented a part of the properties consolidated at the time of the organization of the company that held the land.

In the case of anthracite property the mine workers' statement referred to argues that "holding reserve coal land over a long period is not a mining proposition but a real-estate business." The holding of such land is, indeed, a matter of speculation; and if the speculator be successful, he expects not only to recover his original investment but also to receive very generous interest compounded at frequent intervals for the entire period of his ownership. And the coal user is compelled to pay the bill.

The practice in America has always been that the far-seeing individual might secure ownership rights to coal or mineral deposits. Even deposits for which there was no prospect of development over many years to come, have thus passed into the hands of individuals or corporations and have been held at nominal valuations over long periods. In the case of coal lands, however, the tendency to scrutinize earnings has resulted in a desire to hold large reserves and to value such reserve properties at very generous figures, in order to make the apparent percentage of earnings less. In fact, the Federal Trade Commission in a recent report to Congress states that 79 per cent of the total investment of a certain group of bituminous coal companies was investment in excess reserves.

Deposits of coal have been provided by nature most generously in the United States. It would seem that nature intended this mineral for the use and comfort of the entire nation. But the scheme that has been

developed seems rather to be working out for the gain of certain individuals.

The American nation is passing out of the provincial stage, and the public well recognizes this fact. It is quite willing that the packing house shall replace the neighborhood butcher and that the large units in industry be recognized as one of the natural consequences of mutual interdependence of the trades and businesses of modern life. It is even willing to pay generously for strawberries in January in order that it may satisfy its tastes and whims. But it is not ready to pay unduly for exaggerated and unearned returns upon investments of nominal size in natural resources, especially when they are subsequently exploited for private gain at the expense of the public purse.

The public will pay willingly for labor, material or money required in the maintenance of commerce and industry. It will pay more than willingly, even generously, to anyone who makes constructive, aggressive, far-seeing plans that are really of service to the community. It begrudges no man even a tremendous income if he makes it through genuine contribution to the common welfare. But the public does, and will indefinitely, resent anything that assumes that industry and human comfort are to be permanent vassals to the investor.

The Federal Coal Commission will do well thoroughly to study the questions of unearned investment "values," which the anthracite mine workers have proposed.

Economy and Economist

EVERY once in awhile someone announces the discovery of a means of utilizing the energy of the sun's rays, this time it is a college student. Whether or not the young inventor has discovered something, there is no harm done. But when the Dean of this college allows himself to go on record for the statement, "While I am not prepared to comment upon the feasibility of capturing the energy of the sun, I will say as an economist that the man who invents the method, patents it and gets the legal right to do business will in a few years make Henry Ford look like a pauper," he not only lays his reputation as an economist open to question, but also may unintentionally lend his influence to fake stock-promoting schemes. Furthermore, men that make great scientific discoveries are not generally those who have the business ability to become Fords or Rockefellers or Carnegies.

So far as utilizing the heat of the sun for power purposes is concerned, it has already been done in a number of different ways, but none of them has proved commercially successful. Any means that may be devised to do this must compete with other methods of producing power from fuel and waterfalls. Neither of these sources costs anything until we begin to use it. The cost of obtaining power from either is in making it available and in conversion. Our principal fuels have to be taken from the earth and transported to a power plant where equipment is installed to convert them into a form of energy that is easily transmitted, which is generally electrical. With water power, diversion and retaining works must be constructed to bring the water to the plant where it can be utilized, and these operations must be paid for in the cost of power. So it is with any device for utilizing the heat from the sun; means must first be provided for directing it into channels where it can be used, and a careful analysis of the difficulties of doing this will not make the scheme look very promising from an economical standpoint. To utilize the sun's rays for power purposes is similar to producing power from very low-head rivers, the volume that must be handled in either case to obtain an appreciable power makes the proposition uneconomical. Making use of the sun's radiant heat is further complicated by the limited periods during which it is available. The only economical methods of utilizing the sun's heat for power purposes have so far been provided by nature; chief among these is our waterfalls.

There has been much speculation as to the possibility of converting the energy of the sun into electricity directly. Should a way be discovered to do this economically, will it not mean that a method has been found to convert the heat energy in coal directly into electricity economically? In a boiler a very large portion of the heat put into the water is done by radiation, and this is the form in which energy is obtained from the sun, therefore anything that might prove successful in one case will in the other. However, unless what is known of the laws of nature is to be reversed, the high-head heat method as obtained in a furnace will prove the most economical. Although much has been said about conservation of our fuel resources, it is nevertheless a dollars-and-cents proposition. If it were only a case of conserving fuel, there are many things that we could do, but they will not pay the charges and are therefore uneconomical.

Professional Ethics

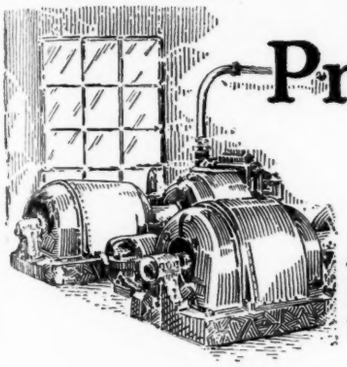
WITHIN the last few years several of the engineering societies have adopted codes of professional conduct. Many have lost sight of the fact that the American Institute of Electrical Engineers was a pioneer in this respect, having adopted such a code as early as 1912, largely through the efforts of Dr. S. S. Wheeler, who furnished the initial stimulus in his presidential address of 1906. The American Society of Mechanical Engineers adopted its first code of professional ethics in 1914 and a revision of it at the annual meeting last December.

Since 1912 there has been a standing committee on principles of professional conduct which from time to time has investigated and reported on cases coming within the scope of the code. The very nature of its activities, however, has precluded publicity with the result that the Code was little known to many of the members, especially the newer ones. Hence, the Institute has found it advisable to republish the Code at this time with a view to impressing upon its members the ethics of the profession, and secondly, we suspect, with a view to reaffirming its justly deserved priority.

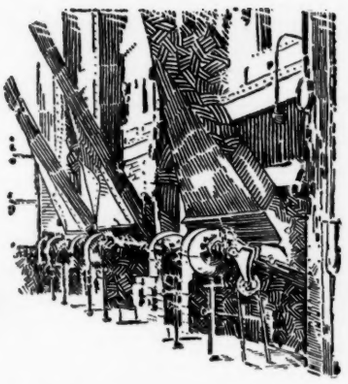
Unless means are adopted to keep such codes constantly before their respective memberships, the experience is likely to be repeated among the other societies that have more recently adopted rules of professional conduct. There is no reason, however, why they should not prove a dominant force in the engineering profession just as they do in the law and medical professions.

Those who believe that hot water heating boilers are perfectly safe and do not explode are advised to read the account on page 421 of this issue.

Backers of Henry Ford in the Muscle Shoals project will be heartened by the St. Paul decision.



Practical Ideas *from* Practical Men



Cutting Down the Waste of Coal

An important fuel-economizing consideration is the use of cheap gases in the internal-combustion engine, controlled by the more dependable use of steam power. This offers the practical possibility of cutting down the cost of power two-thirds, as compared with steam power alone.

Probably the most valuable influence that could be exerted in saving fuel, for some time to come, would be the establishment of schools for the training of combustion "doctors." These should not have the expensive and *unfitting* training of the mathematical mechanical engineer. I use the word "unfitting" intentionally, because very few thoroughly fitted mechanical engineers would care to undertake the practical drudgery of daily or frequent oversight and advisory direction of the rank and file of coal users at the price that the coal users could afford to pay. The malpractices of many coal users are due to an ignorance of combustion processes, which could be largely overcome by the service of a specially trained body of men. Such combustion doctors would hold the same relation to the thoroughly and expensively trained mechanical engineer that the trained nurse does to the medical doctor.

A valuable principle that can be widely applied in fuel conservation, but which is at present very seldom applied, is that of the vertical counter-current heat exchange in the boiler as well as in the economizers. Enormous aggregate amounts of heat that are continually going to waste can be saved by practical applications of this principle in boilers and in preheating air for combustion.

A worth-while method of fuel conservation is the simple practice of securing transmission of the heat of burned gases through heating surfaces under a maintained pneumatic pressure *greater* than that of atmospheric pressure, instead of the lessened pressure of the induced draft, but with a slower rate of travel of the gases over the heating surfaces than what is usual in forced draft.

Again, the relatively low degrees of radiated heat, as well as the heat in exhaust steam may be used to preheat air for combustion. This can be done in the simplest manner and at slight cost. Yet stupendous aggregate amounts of such low-temperature heat are continually being thrown away in power generation.

In steam heating, vast amounts of heat are diffused into the atmosphere and thus wasted, because of lack of provision for varying the area of radiating surfaces of steam radiators. This great aggregate waste is easily preventable.

Recognizing the fact that every fuel-burning device is a gas generator in which the gas produced should be completely burned as it is produced, it would seem that easily applied methods of accomplishing that result should have been generally understood generations ago. But the fact is that today, even among the more intelligent classes of fuel users, a probable aggregate loss occurs of over 20 per cent of the coal that is mined. I have yet to see a steam-power generating plant in which a continual preventable loss of at least 10 per cent is not occurring.

The greater part of the earth's coal deposits should undergo a preliminary preburning preparation to secure the most economical results in their use, through gaining a better equalization of the rate of combustion and preventing air dilution of the burned gases. The latter, including domestic cookery as well as steam generation, is probably the largest single avenue through which fuel wastes occur. If all fuel were coked, and the gas driven off economically used, the coke could be used to great advantage as a matrix for admixed fuels. All soft coals and lignites should be coked before burning, and the coke product used in proper-sized particles for burning unmixed, or else as component parts of special mixtures suited for various purposes, including gas manufacture and power generation.

Such preburning preparation of fuels, opens up the opportunity to overcome the widespread losses from air dilution that are continually occurring because of the natural defects in most fuels. Even with the highest grades of small-sized anthracite great benefit can be secured by preburning preparation. The fine coal dust that is now thrown away can be conserved, as well as the waste of unconsumed cinders, which comprise over one-half of the bulk of ashes from anthracite coals. A beautiful fuel gas can be made from such discarded carbon particles.

Probably, in every coal-burning plant, to secure the best results, all coal after proper preparation should be burned in beds so thick that air dilution cannot occur from excess introduction of air for combustion through the fuel bed. But in those cases the unburned gases rising from the fuel cannot be entirely united with enough air outside the fuel bed, without admixture of the gases with air mechanically applied at determined favorable points. Induced draft, where operated by other than unsaveable heat, should be discarded. As a matter of public hygiene exhaust gases of combustion should be carried in tall exhaust conduits to a high level above the ground line, and there atmospherically diluted, and as the last few degrees of low temperature heat cannot be conserved otherwise, they can be utilized to produce some draft. But even with such induced draft mechanical draft pressures should always also be

applied through electrically driven fans or blowers. There are over thirty avenues through which heat wastes occur that can be practically closed and over one-half the waste of coal that is continually going on can be prevented. In bringing this about good money can be made by those engaged in the conservation, along with great benefit to the world of the future. Individuals usually work for the benefit of their immediate posterity. The public at large should work for the benefit of posterity at large, through governmental action. The Bureau of Mines is doing some good work, but what is accomplished is only rudimentary work, a drop in the bucket, and is mostly for the benefit of experts who do not need such help. The last great coal strike should awaken the public to its duties and possible benefits in connection with fuel conservation. *Individual* activities are not accomplishing a great deal in this connection.

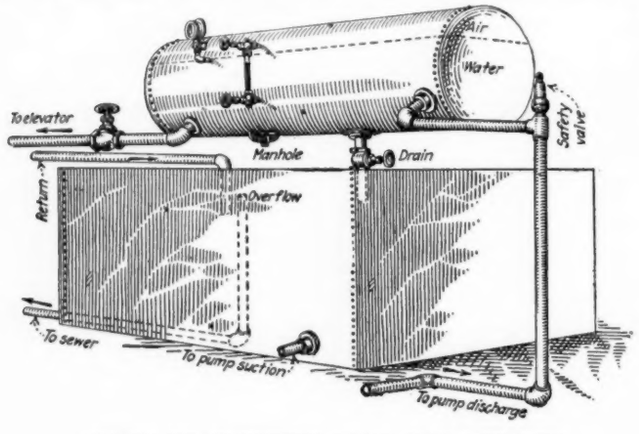
East Orange, N. J. J. M. W. KITCHEN.

Treating Inside of Hydraulic-Elevator Pressure Tanks

The elevator regulations in Massachusetts require that pressure tanks for hydraulic elevators shall be cleaned at least every two years. The figure shows part of one of our equipment that had to be cleaned as recommended by the elevator inspector.

The water was drained out on Saturday night and two men tackled the job Sunday. After the slush was washed out, the rust spots and blisters were scraped off and given a touch with a wire brush. When the inside had been thoroughly cleaned, it was given two coats of cement and water, the first coat very thin, the next about as thick as paint.

Nothing was thought of the job until we inquired from the foreman of a local elevator company. He explained how they give the inside of the tank a coat of asphaltum paint and how they work in five-minute



INSIDE OF PRESSURE TANK WAS TREATED WITH PORTLAND CEMENT

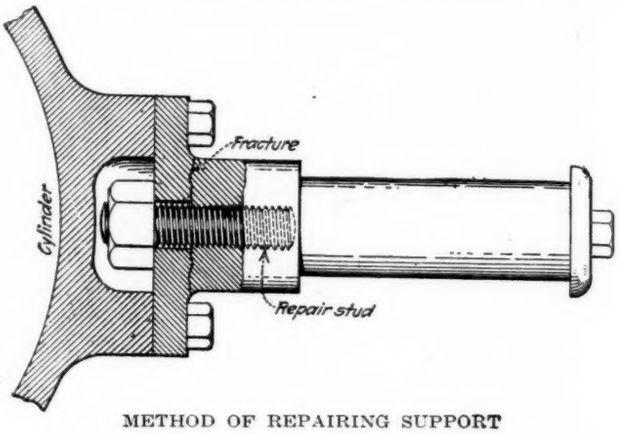
shifts with a man at the manhole, watch in hand to keep time, and frequently a man would have to be dragged out that could not stand the fumes of the paint. There is no way of circulating air through the tank as the manhole is in the bottom side. It is evident that the elevator company makes an expensive and disagreeable job out of treating the inside of the tank. With the cement coating two men make a quick and easy job that lasts longer and stops corrosion.

Springfield, Mass. THOMAS SHEEHAN.

Repair of Wristplate Support

While a double-eccentric Corliss engine was being shut down, the link rod that connects the admission-valve wristplate with the head-end valve arm, broke near the connection with the arm. In falling, the broken end of the rod met the arm of the head-end exhaust valve with the result that the hub of the wristplate support was fractured as shown in the cut.

Why the break occurred here instead of at the root of the wristplate stud, where the cross-section of metal



METHOD OF REPAIRING SUPPORT

is much less, was a puzzle to the engineer until an examination of the break showed traces of an incipient fracture that probably was there when the support was made.

The engineer removed the flange of the support from the cylinder, clamped it solidly to the broken hub on the faceplate of a drill press and drilled a 1-in. hole through both flange and hub. The hole in the hub was then bored and tapped for a stud, 2½ in. long, and the hole in the flange was bored just large enough to clear the stud. The flange and hub were then drawn together tightly with a nut.

The companion flange on the cylinder, for receiving the flange of the support, had been cored out in the center when the cylinder was cast. This provided a cavity for the nut. A. J. DIXON.

St. Louis, Mo.

Wide-Awake Engineers

It is becoming more needful as time passes, for power-plant engineers to keep wide awake to their possibilities. The central-station way of going after business has compelled more than one engineer to discard his lax methods. In the modern power plant the duty hours are busy ones, although it does not follow that they are necessarily laborious.

Employers now want results and the facts and figures showing how these results have been secured. The management often now expects as good results from their operating engineer as they formerly expected from the service of the professional consulting engineer. This illustrates the fact that the status of the power-plant operator is rapidly rising. The modern engineer has much to say with reference to supplies, wages, etc. He must be familiar with fuel and flue-gas analysis, water evaporation per pound of coal and many other factors, and must keep and be able to analyze various kinds of records, charts and reports. Any day something may

turn up which will compel him to study up on subjects that in general might be considered outside the power-plant field.

One thing that has helped many an engineer is writing short articles for the power-plant journals. This work may require the looking up of considerable data and every time such a search is made the one doing the work learns something. It may be that he only relearns something which he had forgotten, but even this is worth while. Writing for publications also teaches the writer to be careful about what he writes, as engineers as good or better than he may read the article and would be sure to note any serious mistake.

Toronto, Ont., Canada. JAMES T. NOBLE.

Sympathy with the Plant

The title of this article may appear to be out of the ordinary, but every engineer who has had any experience with the operation and maintenance of power-station machinery will appreciate its significance. They will agree that boilers, turbines and the other accessories that go to make up the station equipment are much like human beings; they need understanding, and their peculiarities and eccentricities allowed for and administered to.

The troubles and irregularities that develop from time to time in the different pieces of equipment can usually be traced to some specific cause. In the operation of a steam turbine, if foreign matter is allowed to enter the oil system with the oil or the steam casing with the steam, trouble is sure to be experienced, either with hot bearings in the former case, or damaged vanes in the latter, and the set will have to be taken out of service for awhile until the necessary repairs have been made.

Again, a steam turbine when first erected could not be expected to start off satisfactorily if the full pressure of steam were suddenly given to it and it were run up to speed in a few minutes. Steam must be turned on slowly at first, the rotor just being allowed to turn over until all the parts under steam are at practically the same temperature, and the difference in expansion between the several parts reduced to a minimum. The turbine speed can be slowly increased when quite hot, but at the slightest sign of vibration it should be immediately shut down. When the rotor has stopped turning, it can again be run up carefully until the point where the vibration occurred is smoothly passed.

The running of a turbine carefully and sympathetically for the first time, often saves a considerable amount of future trouble. Cases are on record where negligence at the beginning has caused a vibration to be set up that has never been wholly eradicated, whereas had a little care been exercised in the first instance all would have gone well.

The same consideration should also be shown to boilers. For instance, when raising steam, the time between starting the fire and full steam pressure should be of sufficient duration to obviate the possibility of dangerous strains being set up owing to unequal expansion. Boiler arches when new should not be subjected to the full heat of the furnace until they have been properly dried out, and it is good practice to allow a small fire to burn on the grate for at least 24 hours before the boiler is put into active service.

Also when the tubes are allowed to become dirty through soot and scale deposits more heat passes away to the chimney than would be the case if the tubes were clean. The boiler efficiency is also lowered, as less work can be obtained from it.

Suddenly opening steam valves on to a cold header is a dangerous procedure, which shows a lack of sympathy with the plant, and although this is a step that no qualified engineer would take, in small plants where unskilled labor is employed it frequently occurs.

To return to the engine-room, it is frequently found that nuts in accessible positions have been battered about in a disgraceful manner. Workmen have used chisels or calking tools for loosening them where a spanner could readily have been applied, and this goes to show that the men who have been guilty of these acts have not been in sympathy with the machinery on which they have been working.

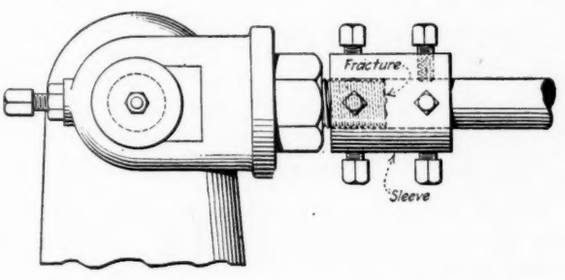
Enough has been said to show that machinery of every description should be treated with a certain degree of respect; it should be understood and handled intelligently, and the impossible should not be expected from it; it should be kept clean and operated in clean surroundings.

When this is done, the engineer will learn to regard the different units under his care as his own particular charges, will know where to look for trouble when it occurs, and will develop that pride and pleasure in his calling that it should be every engineer's ambition to attain.

J. J. SIMMONS, Ch. Asst. Engineer,
Bombay Elec. Supply & Tramways Co., Ltd.
Bombay, India.

Emergency Repair of Engine Reach Rod

The threaded end of the reach rod on a single-eccentric Corliss engine snapped off while the engine was being warmed up for the day's run. There were no facilities at hand for repairing the rod by welding on a new end and threading it in a lathe; still the nature of the work



METHOD OF MAKING TEMPORARY REPAIR

that was going on demanded that the engine be kept running if it were possible to do so. The engineer solved the difficulty by making a temporary repair as shown in the sketch.

The broken end was 1¾ in. in diameter. A sleeve consisting of a piece of 2-in. double-extra heavy pipe about 5 in. long was drilled and tapped at each end for four ½-in. cup-pointed set screws, spaced equidistantly around the pipe. This sleeve was slipped over the fracture and the setscrews were tightened. The engine was kept in service for a week with this repair. Apparently, it could have run on indefinitely.

St. Louis, Mo. A. J. DIXON.

Comments from Readers

Should Steam for Heating and Process Be Charged to Power-Plant Costs?

In the Jan. 16 issue Mr. Maconnell asks, "Should steam for heating and process be charged to power plant costs?" It is almost self-evident that all the expense of making steam should not be lumped into the power plant costs, but the points of division and relative proportioning of the different items of expense will depend on the purpose for which the cost figures are being obtained. Cost keeping and distribution is a waste of money unless use is made of the figures for checking up periodically the progress made in improving conditions and reducing costs, and should be arranged in sufficient detail so that when a rise in costs does occur the cause can be readily located and the proper remedy applied.

For a condition such as is being discussed, the power plant may be considered as a factory, one department of which, the boiler room, manufactures an intermediate product, steam, part of which is sold directly to the mill and part is utilized in the engine room in the generation of power which in turn is also sold to the mill. Therefore, to obtain a fair idea of the cost of each of these two items, all items of boiler-room expense, coal, water, supplies, labor of the fireroom force and such portion of the chief's and repair men's time as is devoted to the boiler room, should be charged up against the cost of making the steam and the factory charged with its proportion as shown by meters on the different lines. Usually, remarkable savings can be made by bringing home to the mill foremen in this way just how much a thousand pounds of steam costs and how easily it can be wasted by reckless bypassing of traps or unnecessary heating of tanks, etc.

The engine room then takes its steam at the same price and, adding its labor and supplies, converts it into power. Totaling this expense against the current supplied to the mill will show the chief what his operating expenses are and will give him an idea whether he is within a reasonable distance of results obtained in other similar plants.

Where exhaust or bleeder steam is supplied to the mill, the cost distribution is slightly more complicated, as this is in the nature of a byproduct and, as in most other industries, its value is determined largely by the market for it. In most cases the fairest method of arriving at the value of this steam is to determine how much expense it requires to produce the power, while supplying the bleeder steam, and also to determine what it would be possible to produce this power for under the most economical conditions of which the plant is capable, and charge the difference as the cost of the bleeder steam. Similarly, where engines are installed and exhaust steam is used for heating in winter, the cost of this steam is the difference in expense between operating the plant as installed and what might be done with the most economical equipment that could be operated under the plant conditions.

This may, and usually will be, less than the cost of an equivalent amount of live steam, but the power plant is surely entitled to credit for the exhaust supplied.

Another factor influencing the assignment of charges to different items of expense is the purpose for which the cost is being prepared. For instance, if a plant using process steam were considering shutting down the prime movers and buying power, the cost at which the public-service company would have to furnish power would be determined by the difference in cost of operating with and without the prime movers, and also to pay off the value of the prime movers above what they could be sold for, in a reasonable length of time. A consideration of much importance in a case of this kind, but which it is usually difficult to assign a definite value, is the relative reliability of the power supply from the two sources, and its effect on the cost of production in the mill.

For instance, at a coal mine where the refuse or unsalable coal does not provide all the necessary boiler fuel, from a strictly accounting standpoint, the salable coal used in the plant should be charged at the cost of production, as the company has spent no more money on it; but if figures are being prepared to ascertain whether it is advisable to shut down the plant and purchase power from a public utility, the coal should be charged at the average market price it could be sold for if it were not required for use at the plant.

Similarly, where a waste product such as wood refuse is supplied to the boiler plant from the mill, the plant should be charged its market value as kindling, and if this is greater than an equivalent amount of coal, it should be marketed as kindling and coal bought for the plant.

H. D. FISHER.

Colver, Pa.

Putting Alternators Into Service After Excitation Has Been Lost

With regard to the inquiry of H. G. Ingalls in the Jan. 30 issue on getting units back into service safely after an interruption, I agree with the opinion expressed by Mr. Tompkins in the Feb. 27 issue, that in most cases the safest and best method is to clear the bus and switchboard and start anew. In general it should not take more than two or three minutes to re-establish the service if the operator is onto his job, although this depends to some extent on whether the auxiliaries are steam or motor driven, for where these are motor driven and the starters are equipped with a no-voltage trip, it necessitates restarting each auxiliary and restoring the vacuum and circulating-water flow to normal before much load can be safely put on the main units. If, on the other hand, the auxiliaries are steam driven, this service will be maintained at normal, and provided the emergency trip on the turbine has not operated, no attention will be necessary to the prime mover, as this will automatically pick up its load, so with the possible exception of starting up a steam-driven exciter, the operating of the switch board requires only a short time.

Where the auxiliaries are all motor driven, in my opinion, it is advisable to have the no-voltage trip eliminated, so that when an interruption occurs the starter will stay in the running position, and by building up the voltage slowly on the auxiliary bus or by the exciter, all the auxiliaries can be brought up together and the service restored to normal in a minimum length of time.

In many cases the delay in restoring service is due to a misunderstanding of signals between the engineer and the switchboard operator or between the engineer and his helper. If this is to be avoided, some definite method of procedure should be outlined by the chief engineer or some competent executive and the operating force well drilled to those instructions. In this way no time should be unnecessarily wasted in restoring the service. E. A. CURTIS.

Cleveland, Ohio.

Half-Size Governor Valves for Small Turbines

The article on half-size governor valves for small turbines, in the Jan. 30 issue, by J. Elmer Housley, suggests a similar experience which I encountered several years ago and solved in a somewhat different manner.

A 2,000-kw. generator was excited by a 35-kw. turbine set, operating condensing at 140 lb. pressure. The generator ordinarily carried 800 kw. load, which sometimes dropped as low as 250 kw. The turbine-driven exciter was operated at a comparatively light load, and after having been in service ten days, it tripped on account of overspeed. The governor valve was found to be badly cut; this we repaired and tried again. After an interval of two weeks a similar trouble was again encountered.

In order to overcome the cutting of the valve due to throttling at light load, a reducing valve was placed between the throttle and the steam turbine, with one gage between the reducing valve and the steam chest and another between the governor valve and the nozzle. The governor valve had a maximum travel of $\frac{3}{8}$ in. from no load to full opening. The reducing valve was adjusted so that this was required to give an opening of $\frac{1}{16}$ in. when 800 kw. was carried on the generator. It has not been necessary to examine the governor valve since this was tried.

The following readings were taken with the reducing valve adjusted so that the governor gave a $\frac{1}{4}$-in. opening: Steam at the throttle, 140 lb.; steam between reducing valve and governor valve, 40 lb.; gage reading between the latter and nozzle, 25 lb. The governor valve was therefore throttling from a pressure of 40 lb. down to 25, and the opening of $\frac{1}{4}$ in. gave no opportunity for steam wiredrawing. The governor valve operated on a differential of 15 pounds.

Since that time the load has increased to 1,700 kw., and on account of increased exciter load, I have had to raise the pressure between the reducing valve and the turbine to 70 lb. in order to obtain $\frac{1}{16}$ in. opening of the governor valve, which gives 45 lb. pressure on the point leading to the nozzle, and therefore a differential of 25 lb. is produced by the action of the governor valve. This gives good turbine regulation.

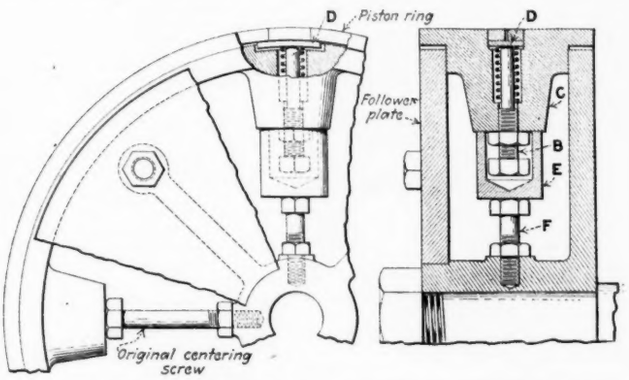
From the viewpoint of engineering economy with coal at $10 a ton, this may not appear to be good practice, but on the other hand, the interruption of a 2,000-kw. machine will cost a good deal more than coal or repair parts, not to speak of the queries of the management as to whether the trouble lies with the machine or with the engineer. H. L. WILLIAMS.

Everett, Wash.

Why Does a High Steam Pressure Produce a Click?

In the Dec. 19, 1922, issue J. A. Watt asks why a high steam pressure produces a click. Some years ago I had similar trouble with a new Corliss engine of the same size and speed. After doing about everything I could think of, I went to the factory and got a clue to what I afterward found was the cause of the trouble.

The noise was caused by the packing ring overriding the counterbore at the head end of the cylinder. When the steam valve opened, it forced the ring downward in the slot until the piston was again inside the bore of the cylinder. The original centering screw was removed and a capscrew *B* put up through the recess in the bull-



SHOWS DETAIL OF PISTON AND LOCATION OF ADJUSTING SCREWS

ring *C*. The piston ring was in sections with a half lap joint over the shoe *D* as shown. The screw went up through the center of the spring and was adjusted so that when the piston ring was against the cylinder wall, it cleared the botton of the shoe *D* about $\frac{1}{64}$ in. Then the cap *E* was put on to obtain a flat surface for the centering screw *F*. When the engine was started again, the click had entirely disappeared and did not recur for several months, but finally when the ring had worn down to some extent it was necessary to readjust the screws.

Richmond, Ind. HOWARD GLUYS.

Since the click occurs only when the steam pressure reaches a certain point and above that, it would indicate that the cutoff occurs too early in the stroke and that the steam is being expanded below the pressure of the exhaust, producing a vacuum in the cylinder and causing the rings to collapse partly. Steam entering the cylinder causes the rings to snap against the cylinder walls, making a disagreeable noise.

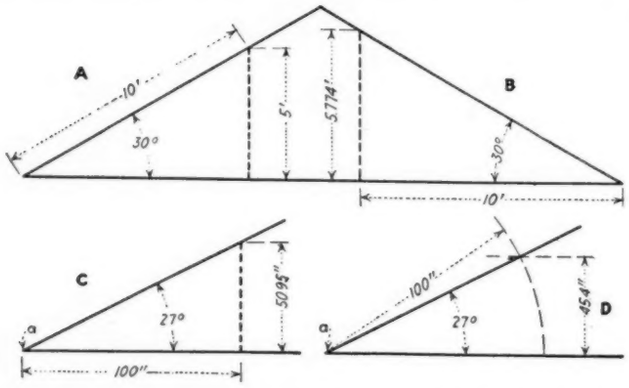
I had a similar experience with a high-speed engine. No amount of oil, changing of the piston clearance or valve travel would stop this trouble. It was finally remedied by boring two small holes, $\frac{1}{16}$ in. in diameter in both sides of piston just below the rings. This broke the vacuum, and the rings were then retained against the cylinder wall. E. J. SCHAEFFER.

Kansas City, Mo.

Easy Lessons in Engineering

Practical Uses of Sines and Tangents

The purpose of this lesson is not to tell all about trigonometry, but rather to explain a few simple facts from trigonometry that are worth as much to the operating engineer as all the rest of the subject put together. This "cream" of the subject is contained in a clear understanding of the meaning of two words—



"sine" and "tangent." These are nothing but two ways of measuring an angle without using degrees.

Consider, for example, a shed roof as outlined at the top of the accompanying figure. Suppose that the angle of the roof to the horizontal is not known and that there is no handy means of measuring it directly. It is, however, found to be a simple matter to measure 10 ft. on the slant, as at *A*, or on the horizontal as at *B*, and to find the corresponding "drop" or vertical distance. At *A* it is found that the drop is 5 ft. for every 10 ft. on the slant, while at *B* the same angle shows a drop of 5.774 ft. for every 10 ft. on the level. Then we have found that the angle is such that there is a drop of 0.5 units for every unit on the slant, and 0.5774 units for every unit on the level. The first of these quantities is called the "sine" of the angle, and the second the "tangent."

The accompanying table gives the sines and tangents of angles from 0 to 90 deg. by whole degrees. From this it is seen that the angle is 30 deg.

If it is desired to split degrees, more extensive tables can be found in the engineering handbooks. It is evident at once that such a table enables one to measure or lay out any angle without a protractor.

To lay a pipe with a pitch of 5 deg., the fall must be 0.0872 ft. (about 1 in.) per slant foot, or 0.0875 ft. per horizontal foot. This can be seen by looking up the sine and tangent of 5 deg. As might be expected, the sine and the tangent are practically equal for small angles. In other words, for small angles the difference between the drop per slant foot and that per horizontal foot is of no great importance. With large angles there is, however, a big difference, as may be seen from the table.

As a general rule, but not always, it is easy to lay out an angle by its tangent. Suppose it is desired to lay out an angle of 27 deg. on the floor. For accuracy make the measured distances as large as possible. Assume that it is convenient to lay off 100 in. on the base line. Then, since the tangent of 27 deg. is 0.5095, the rise in 100 in. must be 100 × 0.5095 in. = 50.95 in. So the layout is as shown at *C*. In this case it would probably be close enough to estimate the decimal fraction of an inch directly.

At *D* is shown how the same angle can be laid out from its sine, 0.454 in. Drive a nail at *a* and strike an arc of 100 in. radius, using a string and piece of chalk. Then draw a line parallel to the base line and 100 × 0.454 = 45.4 in. from it. The other side of the 27-deg. angle must pass through the point where the parallel line cuts the arc, because at this point the drop divided by the slant distance equals 0.454, the sine of 27 deg. It should be mentioned that the sine of 27 deg. is ordinarily abbreviated to sin 27 deg., and the tangent of 27 deg. to tan 27 deg.

SINES AND TANGENTS OF ANGLES

Angle	Sin.	Tan.	Angle	Sin.	Tan.	Angle	Sin.	Tan.
0	0	0	30	0.5000	0.5774	60	0.8660	1.7321
1	0.0175	0.0175	31	0.5150	0.6009	61	0.8746	1.8040
2	0.0349	0.0349	32	0.5299	0.6249	62	0.8830	1.8807
3	0.0523	0.0524	33	0.5446	0.6494	63	0.8910	1.9626
4	0.0698	0.0699	34	0.5592	0.6745	64	0.8988	2.0503
5	0.0872	0.0875	35	0.5736	0.7002	65	0.9063	2.1445
6	0.1045	0.1051	36	0.5878	0.7265	66	0.9135	2.2460
7	0.1219	0.1228	37	0.6018	0.7536	67	0.9205	2.3559
8	0.1392	0.1405	38	0.6157	0.7813	68	0.9272	2.4751
9	0.1564	0.1584	39	0.6293	0.8098	69	0.9336	2.6051
10	0.1736	0.1763	40	0.6428	0.8391	70	0.9397	2.7475
11	0.1908	0.1944	41	0.6561	0.8693	71	0.9455	2.9042
12	0.2079	0.2126	42	0.6691	0.9004	72	0.9511	3.0777
13	0.2250	0.2309	43	0.6820	0.9325	73	0.9563	3.2709
14	0.2419	0.2493	44	0.6947	0.9657	74	0.9613	3.4874
15	0.2588	0.2679	45	0.7071	1.0000	75	0.9659	3.7321
16	0.2756	0.2867	46	0.7193	1.0355	76	0.9703	4.0108
17	0.2924	0.3057	47	0.7314	1.0724	77	0.9744	4.3315
18	0.3090	0.3249	48	0.7431	1.1106	78	0.9781	4.7046
19	0.3256	0.3443	49	0.7547	1.1504	79	0.9816	5.1446
20	0.3420	0.3640	50	0.7660	1.1918	80	0.9848	5.6713
21	0.3584	0.3839	51	0.7771	1.2349	81	0.9877	6.3138
22	0.3746	0.4040	52	0.7880	1.2799	82	0.9903	7.1154
23	0.3907	0.4245	53	0.7986	1.3270	83	0.9925	8.1443
24	0.4067	0.4452	54	0.8090	1.3764	84	0.9945	9.5144
25	0.4226	0.4663	55	0.8192	1.4281	85	0.9962	11.430
26	0.4384	0.4877	56	0.8290	1.4826	86	0.9976	14.301
27	0.4540	0.5095	57	0.8387	1.5399	87	0.9986	19.081
28	0.4695	0.5317	58	0.8480	1.6003	88	0.9994	28.636
29	0.4848	0.5543	59	0.8572	1.6643	89	0.9998	57.290
						90°	1	Infinity

If the angle is near 90 deg., for example 84 deg., it is difficult to lay it out or measure it closely from the sine or tangent. In such cases start by drawing a right angle (90 deg.) and then measure the small angle between (in this case 90 — 84 = 6 deg.) by the methods already described. In the same way if the angle is over 90 deg. work with the difference.

There are countless uses for sines and tangents in the power plant, but space does not permit of other illustrations. They are all, however, based on the same principles, so that the reader who understands the foregoing can make other applications without difficulty.

Burning Pulverized Coal with Reduced Furnace Volumes

Mr. Arrowood argues that by thoroughly mixing coal and air in a proper burner, moderate furnace volumes may be employed and excess air reduced; also by injecting the fuel mixture into the furnace horizontally and at low velocity, temperatures will be highest at the center of the gas volume and lowest at the furnace walls. He describes a burner designed to meet these conditions.

AT the recent annual convention of the Iowa Engineering Society, M. W. Arrowood[1] presented a paper dealing with his company's equipment as designed for heating furnaces of various kinds and discussed the principles of operation. It was his contention that there is no need for the large furnace volumes now employed to burn pulverized coal, provided the fuel is mixed with the proper proportion of air before being introduced into the furnace. Gas, oil and pulverized coal firing are all analogous in that combustion is in suspension. That unusually large furnace volumes are not essential for gas or oil is demonstrated by the fact that locomotives and Scotch marine boilers successfully burn oil. Why then, he asked, should furnace volumes of 5 or 6 cu.ft. per 10 sq.ft. of heating surface be provided for the burning of pulverized fuel? On this basis the 12,000-cu.ft. furnace that would be required for a Mallett locomotive capable of developing 2,000 hp. would be larger than a Pullman coach. At the same time no pulverized-fuel engineer will deny that locomotives with their limited furnaces can be fired with this fuel, and officially quoted tests on certain Western roads have indicated a fuel saving of 25 per cent with pulverized-coal firing.

In two cases, if the volume, velocity, temperature and other conditions of a quantity of gas carrying enough heat to a boiler to develop a given rating, are in all respects identical, how is the boiler to know whether the hot gases of combustion come from oil, natural gas, producer gas, stoker fire or powdered coal? The boiler is built to generate steam and the furnace to generate heat. The latter never should be perverted from its proper function, by introducing features of design calculated to cause it to perform the duties of a feeder or burner. The furnace is not used for atomizing oil; yet those who demand excessive furnace space to give room for air and gas currents to diffuse pulverized-coal particles are doing substantially this thing.

There is no argument against combustion space in itself, said Mr. Arrowood, so long as it is not so excessive as to confine most of the hot gas in a brick box or dutch oven, to the injury of the brick, instead of putting this gas mostly in the zone where exists heating surface in contact with water. The argument is rather to use whatever space is available, in the fullest degree. That process is best which liberates the maximum heat from the fuel, in the smallest volume of the hottest, cleanest, most chemically inert gas, in such manner that the gas may be brought in contact with the work as directly as possible.

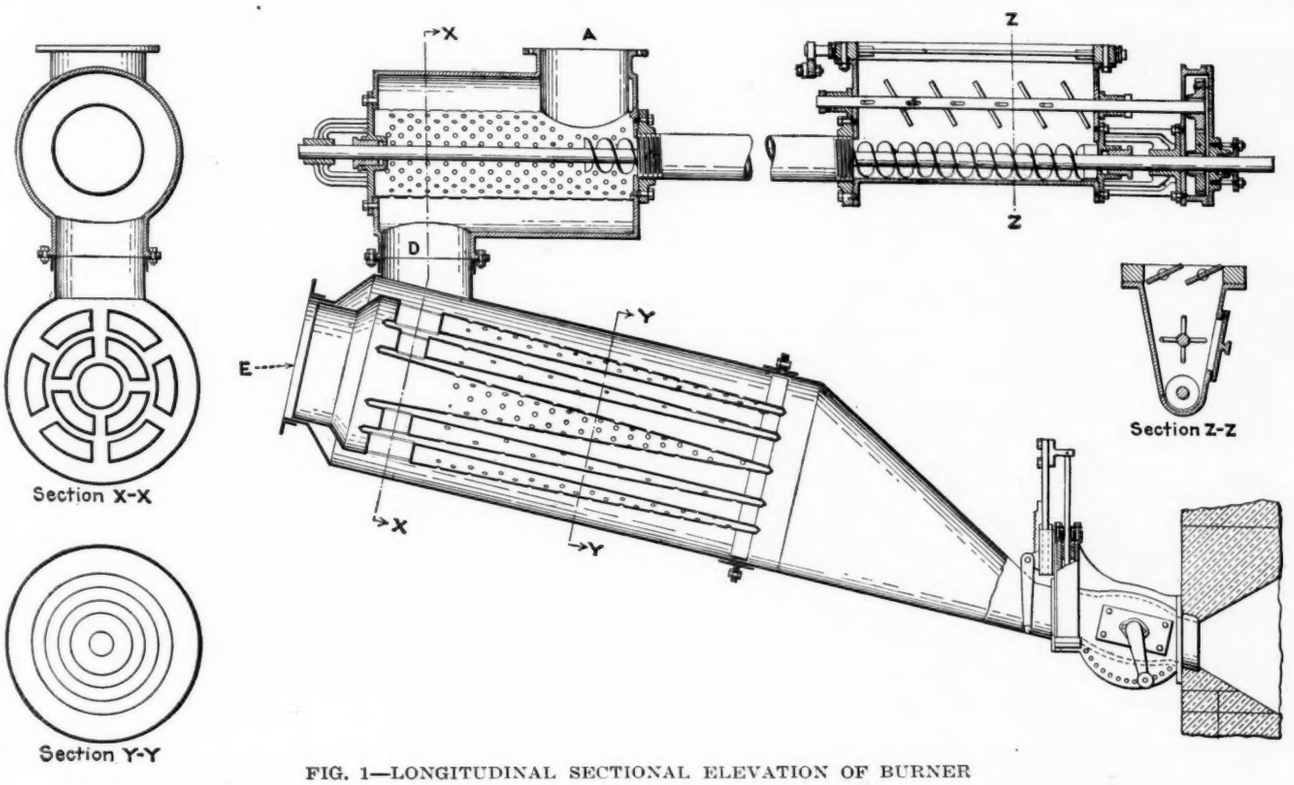


FIG. 1—LONGITUDINAL SECTIONAL ELEVATION OF BURNER

Considering the fact that the volume of air is, roughly, 5,000 times that of coal, even when all excess air has been eliminated, it is seen that the ratio of the spread is great in order that the dust particles may be uniformly diffused throughout the air. Every pound of average Western coal of 13,000 B.t.u. heat value needs theoretically at least 8½ lb. of air. Since a large boiler will require several tons of coal per hour, it is apparent that the volumes to be handled are large, and to feed a complete, evenly diffused mixture of fuel and air into the furnace calls for a mixing and feeding

[1] Of the Ground Coal Engineering Corp., now affiliated with the Sanford Riley Stoker Co.

device that works on an intensive basis so as to complete the diffusion in the apparatus prior to discharging the mixture into the furnace. If such a mixture is not fed, combustion becomes dependent upon a commingling process within the furnace, so that the various fuel particles find only a part, or perhaps some of them all, of the air required for combustion as they are gradually commingled into the gas and air currents within the furnace. Thus combustion is progressive and proceeds throughout the furnace at all points where the breaking-up streams of fuel find enough air for the combustible.

This method of burning progressively involves numerous difficulties in controlling the temperatures as well as in controlling the slag formation and disposition, and also

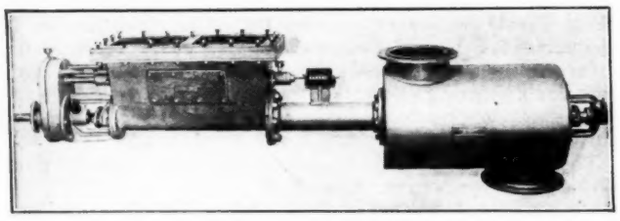


FIG. 2—ASSEMBLED VIEW OF COAL CONTROL

makes it difficult to avoid damage to the refractories by abrading, cutting, streams of material scrubbing the brickwork, or else successively piling up burning particles at or near its surface, thus subjecting it to exceptional temperatures, since each of these particles burning one after another against the brick practically means that the refractory has to withstand something in the neighborhood of theoretical combustion temperatures.

Where a complete mixture is fed into the furnace, the character of flame formation is, in a sense, comparable to that of the bunsen burner, in that there is a point a short distance out from the nozzle which is the geometric center of heat liberation; that is, the hottest point in the furnace from which the gases produced in burning are expanded outward with resulting gradual decrease in their temperature until the brickwork surrounding the furnace is in contact with the gas most remote from the heat center. It is then only necessary to feed the fuel at such a rate as will build up the temperature in the center to the point that gives a gradient of heat flow sufficiently steep to deliver all the heat that the boiler must absorb for the rating desired.

How the Maximum Effectiveness Is Obtained

It seems clear that if this hot zone is brought as relatively near the heating surface as practical considerations permit and, conversely, is as relatively far away from the brick walls (if, indeed, the use of brick walls in a pulverized-fuel boiler be allowed) as possible, the condition for maximum effectiveness in delivering the most heat to the boiler and the least heat to the brick is obtained. Obviously, this calls for a relatively short combustion chamber of considerable height and width, assuming that the firing is to be horizontal, and a complete mixture is fed under normally controlled low velocities.

One argument for unusually large combustion chambers appears to be that a long flame travel is imperative, but apparently the time and velocity features are overlooked. Cutting the velocity of one-quarter or even one-eighth of what is frequently employed, accomplishes the same thing as increasing the length of flame travel, since it gives additional time for burning the fuel in suspension, which, after all, is the object of long flame travel.

It may be worth mentioning that since everyone admits the rate of deflagration and burning with pulverized fuel is exceptionally high, it is probably higher and certainly no lower than the rate of burning of the volatile constituents above the firing bed in the ordinary furnace. If a given rating can be secured on a boiler with gases produced from such a fire bed, what reason is there to suppose that the same rating cannot be secured with similar gases resulting from the same coal fed in pulverized form?

If the mixing, feeding and control apparatus gives accurate control of the relative proportions of air and coal, so that excess air may be eliminated, and with the hottest point of the furnace confined to the center of the gas volume, it should be possible to get more capacity from a given furnace properly fired with pulverized fuel. If, for example, 40 per cent of the space in the furnace has heretofore been occupied by excess air, which cools the gases, and only a small factor, say 10 per cent, has been empirically allowed to permit of ample commingling of the gases, there is, then, a total of 50 per cent space, or one-half of the total volume, which may be used now for productive purpose.

The Multimix Burner Described

As a device that will thoroughly mix the coal particles with 5,000 times their own volume of air before the fuel is introduced into the furnace, the author refers to his "multimix" burner, a diagrammatic longitudinal sectional elevation of which is shown in Fig. 1. It should be borne in mind that the drum on the end of the screw is cylindrical, as is also the burner proper and the perforated screen inside the screw drum. The burner consists of the main mixing barrel, the nose piece and discharge nozzle. Air may be admitted directly to the openings *A* and *E* from a variable-speed fan, or may come from the air line, valves being inserted to give control. These valves may be mechanically connected in synchronism with the speed of the screw and the entire apparatus automatically controlled if desired.

A blast of air admitted at *A* is jetted directly into the coal as it is whipped off by the screw, thus picking up the coal particles and carrying them outward through the perforations in the screen. The spreading jets, issuing from this screen into the annular drum space around it, then impinging on the outer drum, reversing and cutting into each other, thereby set up a mass of eddying currents, all of which are drawn together through the connection *D* and pass thence into the mixing chamber proper.

The burner has four sets or pairs of mixing shells, nested one within the other, the partly mixed material from the coal control being distributed into the outer annular space of each pair by radial crossover tuyeres or tubular connections seen directly under *D*.

Directly above this point a hole about three inches in diameter is left in the bottom of the drum screen, so that in case lumps of material should come to the apparatus, they may work through; and since the annular coal spaces in the

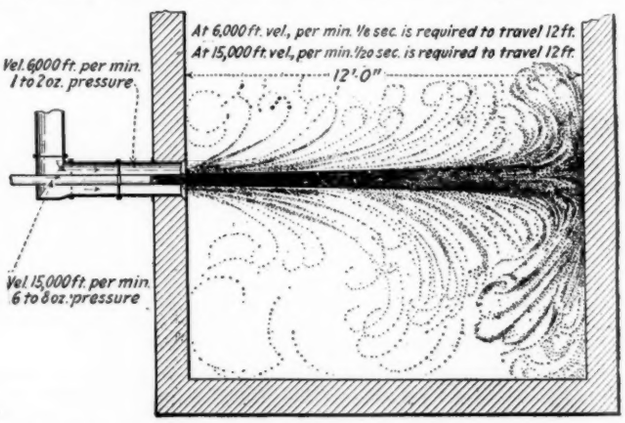

At 6,000 ft. vel., per min. 1/6 sec. is required to travel 12 ft.
At 15,000 ft. vel., per min. 1/20 sec. is required to travel 12 ft.
12'-0"
Vel. 6000 ft. per min.
1 to 2 oz. pressure
Vel. 15,000 ft. per min.
6 to 8 oz. pressure

FIG. 3—ILLUSTRATING MANNER OF IGNITION IN FURNACE

burner proper are fully open at the right-hand end, it is apparent that such particles may work straight through the apparatus and be discharged. The remaining air—that is, about three-quarters of the total—comes into the end of the burner at the point *E* and passes between the radial crossover tubes, going into the center pipe and each of the alternating annular rings surrounding it. The perforations in this pipe and the outer shell of each air ring provide ample means for jetting the air into the partly mixed material, passing through the outer ring of each pair.

Since this outer ring is of larger area than its companion air ring and contains only one-quarter of the total air,

three-quarters being confined in the smaller area, there is a sharp jetting effect through the holes, the jets expanding from their orifices into what tends to be an expanding atmosphere—thus tending to give an ideal condition for diffusing all the air evenly through the mass of coal held in suspension as it travels through the outer ring of each mixing pair. There is a total of 2,072 mixing jets in this burner. The screw drum alone contains 560.

The mixture is discharged into the sloping nose piece, and as the upper parts of the discharging rings are flattened down and sidewise, driving into the lower parts of the same rings, considerable turbulence is set up in the nose piece and discharge nozzle. While it is possible that the reverse

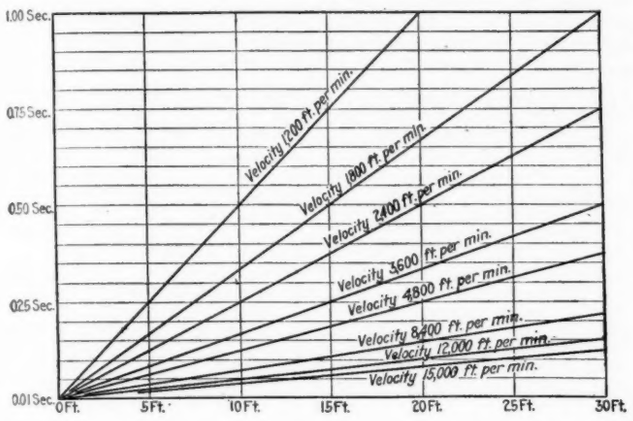


FIG. 4—TIME VS. VELOCITY IN FURNACE

whirls, as indicated in the sketch, may be somewhat exaggerated, the material as it ignites from the nozzle is in a turbulent and whirling condition.

In starting a burner, the order of procedure is to turn on the air, and as soon as it is flowing, turn on the coal, the nozzle damper previously having been opened. This damper works in an inclosed housing, being raised or lowered by two rods passing through glands and attached to the ends of the damper, these rods being operated from a crank at either end of a cross-shaft operating through pinions and racks.

Fig. 2 is a view of the completely assembled coal control, the opening to the hopper being divided by a center rib, and having a total area of 9x27 in., while the drum for the first stage of mixing is 18 in. in diameter and 30 in. long, with outlets 10 in. in diameter. In the housing on one end of the shaft is a set of spur gears which drive an agitator shaft that serves to stir the coal to a uniform consistency, thereby assuring that the screw makes regular constant delivery. The outlet connections of the drum are 10 in. in diameter.

Fig. 3 is a cross-sectional elevation, giving a diagrammatic illustration of the manner of ignition when discharging the mixture into the furnace. When the furnace is relatively cold at the beginning of a firing period, the inside tip of the unignited material will be relatively long, since the temperature is not sufficient to penetrate to the center core of discharging material, especially with a larger burner. As the stream comes forward, the outer film is ignited to whatever depth the temperature is able to penetrate, and at each point along its travel a certain amount of gas is liberated in its combustion. Thus gas is continually liberated along the path of flow, causing the whole mass to expand outward into an elliptical form, excepting as it may be affected by the confining furnace walls.

The firebox shown in the illustration is relatively too small for the size of burner indicated, and therefore shows what the most extreme effect of an exaggerated small furnace may be. The geometric center of heat liberation is just somewhere beyond the tip of igniting material, and it is obvious that the expanded gas in contact with the brick is the coolest gas in the furnace. In a furnace of normal proportions, said Mr. Arrowood, there need be no anxiety as to unusual depreciation of the brick, especially as the inlet velocity with a perfect mixture may be unusually low, ordinarily around 1,500 to 2,500 ft. per minute.

With a high discharge velocity of, say, 15,000 ft. per min., if the coal stream fails to lose its velocity inside of one-twentieth of a second, it will travel entirely across a 12-ft. furnace and strike a bridge wall on the other side with sufficient impact, combined with a heating condition of the jet breaking up against the wall, to destroy the brick quickly. It seems hardly conceivable that much expansion can occur in less than one-twentieth of a second, so it will be conservative to assume that the velocity is maintained for that interval of time.

Fig. 4 is a diagram of time versus velocity in the furnaces, the length of furnace appearing along the bottom of the chart and the time in the vertical ordinate. It will be noticed that at a velocity of 15,000 ft. per min., the total time of passage through a 30-ft. furnace is about $\frac{1}{4}$ of a second, while with a velocity of 1,800 ft. per min., readily obtainable with a mixing type of burner, the time of passage through the same furnace is one second. In other words the time interval is eight times as long, which amounts to the same thing as eight times as much flame travel.

Feed Water Discussed by A.S.M.E. at Brooklyn

The problem of station makeup water, with particular reference to remedies for scale, priming and corrosion, was attacked from several different angles in the meeting which the Metropolitan Section of the A.S.M.E. held in Brooklyn, N. Y., on the evening of Feb. 27. As a preliminary to the discussion, P. W. Swain, of *Power* presented a paper giving a general outline of feed-water troubles and the various methods of treatment. On account of the many ramifications of this subject it was possible for him to touch only the high spots in the time available, leaving a more detailed study of the various systems for the discussion. As Mr. Swain's paper was confined almost entirely to material that has already been presented in more extensive form in *Power*[1] it will not be abstracted here, except to outline the subjects covered. These were as follows: General nature of the troubles experienced with scale, priming and corrosion; effect of modern plant conditions on these troubles; relation of chemical composition of water to its effect on the boiler; elementary principles involved in chemical treatment either inside or outside of the boiler; special methods of scale prevention (open heaters, deconcentrators, live-steam heaters); chemical treatment within the boiler; chemical water-softening systems; zeolite water softeners; evaporators; relation of evaporator installations to station heat balance; causes of corrosion; chemical methods of reducing corrosion; corrosion prevention by deactivation and deaëration.

The paper was followed by about two hours of discussion, in which various manufacturers and operating men brought up points based on their personal experiences and observations. In starting the discussion, George H. Gibson, representing the H. S. B. W.-Cochrane Corporation, emphasized the importance of correlating the feed-water treatment with the general operation of the plant. For example, in selecting a deaërator consideration should be given, not only to any loss of actual heat, but also to losses of *available* heat, due to a temperature drop which could otherwise be utilized for power production. The same consideration applied in the case of evaporators. Mr. Gibson stated that the increasing use of bleeder heaters showed that more attention was being given to the utilization of the available energy in steam before it was used for heating feed water. The deaërating heater, he said, made it possible to take advantage of the full drop down to the temperature of the heated feed water.

W. W. Montalvo Jr., of the same company, next described some of his interesting experiences in inspecting many

[1] During the last half of 1922 in the series of articles on feed-water treatment.

plants in northern New Jersey. It had been his experience that the use of water containing as little as one-third to three-quarters of a grain of sulphuric acid per gallon, made it necessary to remove tubes every two or three weeks, even where the makeup amounted only to 10 or 15 per cent. In such cases, the installation of a chemical softener, with its resulting neutralization of the acids, stopped this corrosion. He called attention to one plant where foaming had been caused by an acid fat in the sewage with which the makeup water was contaminated. This formed, with the magnesia present, a magnesia soap, which naturally caused foaming.

Discussing the moot question of the relation of sodium salts to foaming, Mr. Montalvo said that sodium chloride would cause foaming in concentrations above 200 grains per gallon, but that other sodium salts gave no trouble.

John H. Lawrence, of Thomas E. Murray, Inc., questioned whether economizers would invariably corrode if fed with water containing dissolved oxygen. It was suggested in reply that where the water went to the economizer from an open heater operating at nearly 212 deg., a large amount of deaëration had already been effected by the heater, while with lower temperatures corrosion might be inhibited to a certain extent by alkalies in the water.

An extensive comparison between chemical softening and zeolite softening was made by S. B. Applebaum, of the Permutit Company. The zeolite process, he said, permitted complete softening, while lime-and-soda plants left several grains of hardness in the water. As far as reagent cost was concerned, chemical softening was cheaper than zeolite softening for temporary hardness and more expensive for permanent hardness. This often led to the use of a combination system—with lime for the temporary hardness, and zeolites for the permanent hardness and the remainder of the temporary hardness. He argued for the complete elimination of hardness in modern plants operating at high ratings. In reply to a questioner who asked whether certain impurities in the water such as acids, mud, iron, etc., did not prevent the proper action of the zeolite, Mr. Applebaum said that this was true, but that such impurities could easily be removed before the water went to the zeolite.

George L. Fowler, consulting engineer, told of cases in his experience where extraordinary chemical changes had occurred in boilers operating at 200 lb. pressure. At this pressure and the corresponding temperature, he said, all sorts of things could happen that could not happen under ordinary atmospheric conditions.

Practical Pointers on Foaming

A detailed outline of the causes of foaming and priming was given by Howard L. Tiger, of the Permutit Company. Foaming, he expained, was influenced first, by the design of the boiler, second, by the method of operating it (rating, height of water level, concentration of total solids, etc.), and third, by the composition of the water (oils, suspended matter, etc.). Mr. Tiger called attention to the fact that no general rule could be laid down as to the concentration of dissolved solids which would cause foaming, since it varied all the way from 120 to 800 grains per gallon, according to the nature of the impurities and the method of operating the boiler. The only practical way of handling this matter was to determine, by actual experiment in each case, what concentration would cause foaming. The concentration could then be kept below this point by the right amount of blowdown, this being most satisfactorily controlled with the aid of a special blow-down hydrometer, which read directly in terms of concentration.

Albert A. Cary who, in his work as a consulting engineer has tackled and solved many feed-water problems, gave an interesting account of the action he took with the worst feed water he ever encountered. This particular water, which came from a "dead" lake in Australia and was used for operating Lancashire boilers, contained about 14,000 grains per gallon of total solids (about two pounds per gallon). Even with this enormous quantity of impurities the plant was operated by feeding the water to one boiler operated at a low rate of evaporation, the other boilers being fed with condensate. It was, however, necessary to shut down the distilling boiler every day or two to shovel out the accumulated deposit. Mr. Cary said that it was, in general a mistake to treat water within the boiler by boiler compounds or otherwise. In any case of feed-water trouble he felt that a chemical expert should be consulted.

R. D. Spear, of the Wheeler Condenser and Engineering Co., spoke on evaporators, and called attention to the fact that, after much experimenting, the low-pressure film type had been generally adopted in the Navy. He felt that the type of evaporator best suited to use aboard ship would also be most suitable for land installations. Among the advantages he mentioned were easier scale removal at low pressures and lower feed-water temperatures, with correspondingly better economizer efficiency in installations where economizers were used.

A. D. Blake, of *Power*, quoted Admiral Robson of the U. S. Navy, to the effect that the two main reasons for the general adoption of low-pressure evaporators in the Navy were, first, easier removal of sludge and, second, the large amount of exhaust steam available aboard ship.

Three Important Written Discussions

Several written discussions were submitted. In one of these, H. F. Reynolds, of the Wm. B. Scaife & Son's Co., described the operation of the We-Fu-Go system of water softening, which is of the cold intermittent type. He gave the following as fundamental requirements of a water-softening system to give a standardized result with water from a variable supply: (1) Individual treatment until actual test shows that the right weight of reagents has been added; (2) thorough mixture of the reagents with the water and with the precipitates of previous purification, the latter forming nuclei to assist the new reaction; (3) accelerated chemical reaction due to the thorough mixture of reagents and precipitates by positive mechanical stirring during the entire period when reagents are being introduced and subsequent to the last addition of reagent; (4) complete chemical reaction to stabilize the residual calcium and magnesium, so as to prevent any further precipitation after the water has left the softener; (5) rapid and complete sedimentation by keeping the water quiet during the settling period; (6) efficient filtration under a uniform head.

In another written discussion, S. Morris Lillie, of the Sugar Apparatus Manufacturing Co., went into the application of evaporators in general and of the Lillie low-level film-type evaporator in particular. This evaporator, which was first used in the early nineties, has found extensive application, particularly in the Navy. The company is now prepared to furnish stationary plants with evaporators which would not only supply pure distilled water for boiler makeup feed, but at the same time deaërate the total boiler feed by the flash-down process applied in a number of stages and with a total flash-down temperature drop of 60 deg. or more.

The cause and prevention of corrosion was the subject of a written discussion by J. R. McDermet, research engineer of the Elliott Company. A brief outline follows:

Corrosion in boiler plants occurs in several places—the feed line supplying the feed water to the boiler equipment, steel-tube economizers, cast-iron economizers and in the boilers themselves. In isolated cases corrosion is found in turbine and condenser equipment. As far as the feed lines are concerned, it is ordinarily cheaper to replace them at intervals than to pay overhead charges on deaërating equipment. This, however, does not hold for the other cases of corrosion mentioned. The natural waters in the United States vary greatly in their corrosive properties. These seem to depend largely upon whether the waters are acid or alkaline, although ordinary chemical tests are hardly refined enough for such work. Pollution has a marked effect, particularly where it is from salt water, sewage or stagnant ponds. Such impurities are particularly bad for cast iron, although this material has a remarkable immunity to slightly acid conditions. Wrought-steel economizers are particularly susceptible to acid conditions and high dissolved-air content. By controlling the acidity and removing the air, this corrosion can be stopped. In certain localities boilers have shown rather alarming corrosion, usually in connection with high steam pressures and high rates of evaporation. In such cases deaëration should be advantageous.

Destructive Heating-Boiler Explosion

The hazard attending the operation of a heating boiler is frequently looked upon as being worthy of little or no consideration. In fact, the owners of equipment of that kind have been successful in resisting state and municipal supervision for boilers used in residential heating service. It is logical that a hot-water heating boiler does not possess as great possibilities of destruction as does a steam heating boiler, when each is operated under normal conditions; but unless the design, construction, installation and operation are what they should be, a heating boiler may explode violently.

It is customary to equip a steam heating boiler with a safety valve, so as to provide a means of relief from overpressure, but the majority of hot-water heating boiler installations depend upon the overflow from the expansion tank to avoid subjecting the boiler to the danger of overpressure. There is some question as to the dependence which may be placed in the expansion-tank overflow, as freezing has been known to obstruct that pipe, and in at least one instance, a common mud-dauber built its nest so securely in the overflow pipe under the eaves, that the boiler was wrecked, owing to the overpressure that resulted from the expansion of the water as it heated.

The desire to complete a heating-boiler installation with the least possible expense undoubtedly accounts for the practice of not placing a relief valve on the boiler. This idea of economy likewise accounts for the omission of valves from the flow line and return line in the average installation, so that a hot-water boiler in direct connection with an expansion tank with no intervening valves, has been looked upon as a reasonably safe installation.

However, when there are two or more hot-water boilers used in supplying heat to a system, it is not unusual, although unnecessary, to place a stop valve in each flow line and in each return line, somewhat as indicated at *A* and *B* in Fig. 3. It will be recognized that closing the valves *A* and *B* to either boiler, will completely seal that boiler, and the steam which would be generated or the expansion of the water as heat is applied would more than likely cause an explosion. Should valve *A* in the flow line be closed, with valve *B* in the return line open, the boiler would soon generate sufficient steam to back the water through the valve *B* in the return line, resulting in an empty overheated boiler.

There is no advantage in placing stop valves in any of the pipes connected to a hot-water heating boiler, for if there is more than one boiler connected to the system and the service of only one of them is desired, there is no reason why the idle boiler should not remain filled with water and in direct connection with the system.

Figs. 1 and 2 show the results of a violent explosion of a cast-iron heating boiler, which occurred recently in a residence in Portland Place, St. Louis, Mo. The property damage was large. Fortunately, no one was injured.

It appears that two boilers were connected to the system, each having stop valves somewhat as shown by Fig. 3. One of the boilers had been out of service—probably with both of the stop valves closed. The fireman decided that

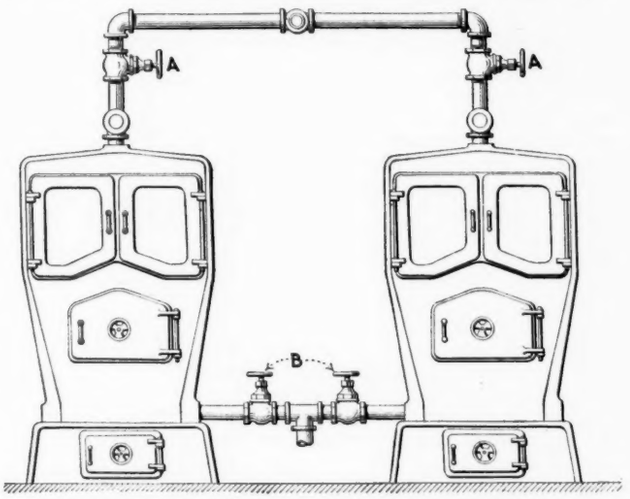
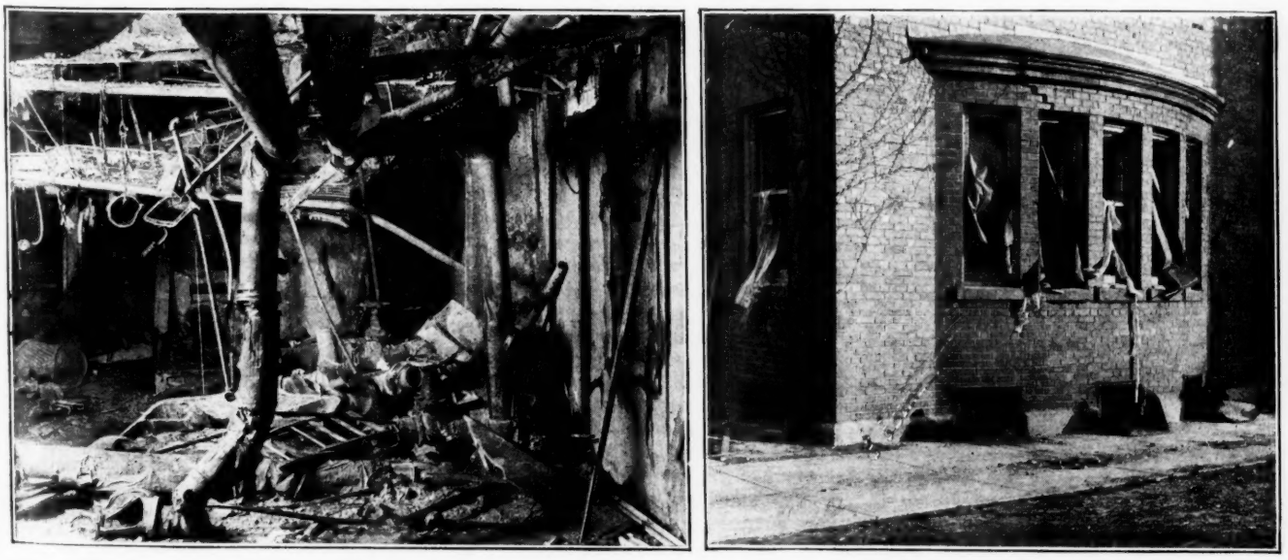


FIG. 3—SHOWS HOW BOILERS WERE CONNECTED

he needed the additional boiler capacity and placed a fire in the furnace of the boiler that had been idle. About an hour and a half later that boiler exploded violently, damaging the other one forming a part of the installation, doing considerable damage to the basement and to the building walls. It will be noticed that all the windows had been blown from the dining room, which was above that part of the basement in which the boilers were located, and the building wall above the windows was dislodged.

The proper authorities arranged for an immediate investigation, and when they reached the premises they found the valves *A* and *B*, serving the boiler that exploded, both closed. The valve *B* was said to have been closed after the accident, but valve *A* remained undisturbed. Either way the explosion would have occurred, but as the damage done indicated a considerable quantity of heated water, it is probable that valve *B* was closed or nearly so.



FIGS. 1 AND 2—RESULTS OF A VIOLENT EXPLOSION OF A CAST-IRON HEATING BOILER

News in the Field of Power

Penn Central Power Co. Building New Station

CONSTRUCTION has begun on the new plant of the Penn Central Power Company at Saxton, Pa. This plant, of 80,000 kw. ultimate capacity, will be tied in with the company's extensive transmission system in and around Altoona, Pa. A near-by mine will furnish coal for the new Saxton plant.

The initial installation will consist of four 11,000 sq.ft. B. & W. Stirling type boilers, equipped with 11-retort Taylor stokers, and two 12,500-kva. Westinghouse turbo-generators operating under 250 lb. steam pressure and 200 deg. F. superheat. Stokers, forced-draft fans, condenser circulating pumps and clinker grinders will be driven by squirrel-cage motors. There will be two condensate pumps for each condenser, one turbine-driven and the other motor-driven.

The electrically driven auxiliaries will be supplied either from a 750-kw. house turbine or from a house transformer bank consisting of three 500-kva. transformers, 13,200 volts to 2,300 volts. The 2,300-volt bus will be in duplicate, one bus being supplied by the house transformer, and the other by the house turbine.

The main turbo-generator and the house turbine generator will be equipped with the faceplate type voltage regulator. This is similar to the installation at the Colfax plant of the Duquesne Light Company.

The Penn Central Power Co. distributes power over a 350-square mile area for use in coal mines, industries, street railways, and for domestic lighting. The main plant of the system is at present located at Williamsburg, near Altoona, Pa. It is rated at 23,000 kva. There is also a combination hydro-electric and steam plant of 7,500-kva. rating at Warrior Ridge.

Federal Coal Commission Voted Requisite Funds

While the continuance of the President's Coal Commission was imperiled by the delay in voting its appropriation, Congress, in an eleventh hour effort gave the Commission all the legislation which it had asked. This included the appropriation of $400,000; the authorization to require sworn answers to questionnaires; the extension of the life of the Commission until Dec. 31 and the authorization for Judge Alschuler to serve as a member of the Commission.

The appropriation was added to the third deficiency bill in the Senate. It was approved with practically no objection. A separate vote on the amendment was demanded in the House, but the item was approved without a roll call. Prior to that action, however, the House had passed the bill which authorizes the Commission to require sworn answers to its questionnaires. The amendments to the original act included the desired increase in the appropriation. The amendments were approved by a vote of 212 to 76.

The Commission had asked originally for authorization to extend its activities to Dec. 31, if that should be found necessary. Since that time the situation that prompted that request has changed sufficiently to make it practically certain that the Commission can conclude its work by Sept. 22, the date originally set. Congress, however, did not take cognizance of the fact that the Commission no longer believes that an extension of its term is necessary and authorized the President to advance the limit as might be found necessary to a date not later than Dec. 31. In commenting on that phase of the legislation, Chairman Hammond stated that he can foresee no contingency that will interfere with the submission of the final report on Sept. 22. There is reason to think, however, that the Commission is glad to have additional time made available to provide for any unforeseen delay.

In the same manner Congress took no note of the fact that Judge Alschuler had tendered his resignation to the President and that the President had accepted it. The action of Congress in authorizing him to serve on the Commission was entirely unexpected, but Chairman Hammond characterized it as the best news that had come to him in a long time.

Pinchot Urges Power Survey for Pennsylvania

Governor Pinchot has asked the Legislature of Pennsylvania for a special appropriation of $35,000 to conduct an outline survey of water and fuel resources available for Pennsylvania and their practical utilization for power development.

The purpose of the survey is to make a careful study of power-development possibilities both within and outside the state. The development of Niagara Falls, the Delaware, Susquehanna and Potomac Rivers and other sources of power is of as great interest and value to Pennsylvania as if these sources were entirely within the State, the Governor explained.

"Such a survey should point out the way to secure for all industries, farms, homes and railroads in all parts of the Commonwealth an abundant supply of cheap electric energy while duly safeguarding existing investments in the electric industry," the Governor stated.

Encourages Coal Storage by Small Consumer

The attention of the Federal Coal Commission has been called to the plan for encouraging coal storage by the small consumer, which was devised by L. S. Storrs, president of The Connecticut Company, large operator of electric railways. Commissioners Hammond and Smith are outspoken in their commendation of the plan whereby the company guarantees payment for the orders of domestic fuel placed by their employees on April 1.

Each employee estimates his winter's requirements and places his order with a dealer not later than April 1. He agrees to accept delivery at any time during the summer that may suit the convenience of the dealer. The company begins the first week in April to deduct from the salary of the employee one twenty-sixth of the cost of the coal. By spreading the payment over twenty-six weeks, each deduction is small and makes for material savings, since it was found to be the practice among many of these employees to purchase coal in quarter- and half-ton lots during the winter months. By this plan no less than 20,000 tons of anthracite will go into storage early in the season in the bins of the employees of this one company.

The plan appeals to Mr. Hammond and Dr. Smith as being business-like, since it requires no special machinery to handle the six months' financing and because it is welfare work of an effective type, as it saves the small consumer the high costs of securing small deliveries in the dead of winter. The plan is to be brought to the attention of large employers in the belief that it offers the opportunity to secure the maximum possible amount of storage on the part of domestic consumers. The Federated Societies expects to call this plan to the attention of large employers, through their engineers.

While it would be outside the province of the Coal Commission to request state legislatures to postpone consideration of pending coal legislation until the Commission reports, Mr. Hammond did point out on Saturday that it is obvious that the state as well as the federal government would be in a position to legislate much more intelligently when it has before it the basic facts which the Commission is assembling.

Answers State's Contention in Water-Power Suit

For the Federal Power Commission, Solicitor General Beck has filed in the United States Supreme Court an answer to the amended bill of complaint entered by the State of New York to test the authority of the Commission. The state claims that it has spent great sums on the development of waterways within the state and has projected hydro-electric developments over which the Federal Power Commission has no authority.

The amended answer of the Commission declares that under the interstate commerce clause of the Constitution, the federal government has authority over the barge-canal system of New York, the canal system being a part of an interstate and foreign commerce waterway. It states that the bill does not join essential parties in that no determination can be made of the authority of the United States to enter into contracts with citizens of New York for the acquisition of real or other property useful in the preservation or improvement of navigation in the absence of the citizens whose property is affected. The state does not present any concrete plan regarding its proposed hydro-electric development or how such plan would affect navigation. It has filed no plans for power development with the Commission, but private persons have done so and these applications are being considered by the Commission.

It is pointed out that the United States government spends large sums for the development of navigation in harbors of New York and on the Hudson River. Regarding the hydro-electric development on the St. Lawrence River it states that this waterway has been the subject of international conference regarding its improvement for ocean-going transportation, and if the state were to construct plants there, the Commission would seek action by the Attorney General to determine the effect.

The Federal Power Commission does not construct plants. Such construction by those licensed to do so by the Commission would not deprive the state from the right of taxation of such properties.

Seeks State Control for Water Powers

Governor Smith of New York Asks Legislation to Give Funds for the Beginning of State Development

GOVERNOR SMITH addressed the New York Legislature on Mar. 5, on the subject of water-power development; briefly stated, as follows:

The Niagara River on the west and the St. Lawrence on the north furnish power possibilities of immense value. The flow of these rivers is unusually uniform, compared with other streams of the state. They stand alone so far as the quantity and quality of available power is concerned.

The state should develop these power resources on these rivers and transmit energy created thereby to every municipality over transmission lines owned and controlled by the state. Under proper management the state can develop these powers cheaper than private corporations. I recommend:

First—That appropriate legislation be enacted to carry out this policy, which means the immediate development by the state of the undeveloped water powers available on the Niagara and St. Lawrence. We should at the same time provide means for the transmission and sale to the municipalities of the electrical energy thereby created. Provision should be made for beginning the work immediately. To do this will require an adequate appropriation of public funds made immediately available.

Second—That the State Engineer be clothed with the power and charged with the duty of beginning development work at once by the most economical plan that will contemplate development and distribution to municipalities by the best methods known. Ample authority should be conferred upon him to enter upon negotiations with the Federal Government for consent to develop hydroelectric power on these streams consistent with its control over these waters for navigation.

Third—That pending the development of all these powers, existing transmission lines should be declared common carriers by law and compelled to transmit energy at a reasonable rate.

Fourth—That no further permits or licenses for the development of power should be granted to any private corporation. The surest way to bring this about is to repeal any statute creating any commission, board or officer already vested with any such authority. Any statute heretofore enacted conferring upon commissions, boards, bodies of any kind, power to grant any right, leave or license to develop water powers that belong to the state should be instantly repealed.

Fifth—$75,000 be made immediately available to the Attorney General to enable him to defray the expenses of the action now pending and begun by the state against the federal government designed to determine the right, control and jurisdiction of the state on navigable waters within its border for power development

The main issue, the cost, has been avoided almost altogether. The Governor does speak about making an appropriation to start some work, but the salient question of raising $150,000,000 is not mentioned.

The administration has committed itself so far to two bond issues for this fall, but only one bond issue can be submitted at a general election. One issue is for $15,000,000 for additional state park land, and emphasized through a fire in an insane asylum, $50,000,000 was recommended for the rehabilitation of state institutions.

Ford Granted Power Permit on the Mississippi

A concession to public opinion in the locality affected was made by the Federal Power Commission in awarding a preliminary permit to Henry Ford covering the High Dam project in the Mississippi between Minneapolis and St. Paul. To guard against non-use such as has followed the construction of the Ford dam at Troy, N. Y., and to safeguard the public interest in other ways, the commission imposed very strict conditions in extending the preliminary permit.

Provision is made to insure the maximum possible utilization of the power. Mr. Ford is required to install four units with the maximum capacity of 4,800 hp. This is all the power that can be developed without extensive and expensive changes in the dam. A further condition imposed by the commission is an annual charge of $95,500 for the use of the government's dam. Mr. Ford is also required to put in a tailrace 2,000 ft. long, so as to prevent the silting up of the navigation channel and the lock. The commission feels that these rather rigorous conditions are necessary in order to insure the use of the power in the public interest.

Mr. Ford is required by the permit to apply for license before July 1. On that date he must present executed contracts for the sale, delivery and use of the maximum power that can be delivered at the dam. This probably means that a large block of the power must be sold to the Northern States Power Company. That company is understood to be ready to purchase such power as Mr. Ford has to sell, but since it is now securing dump power for 2½ mills per kilowatt-hour, delivered, it was brought out clearly at the hearing that the company would not be willing to pay a higher rate to Mr. Ford.

Obituary

James G. Beckerleg, known to brother engineers as "Dad," died at Chicago on March 7, after a brief illness. He was born on May 7, 1833, in St. Ives, Cornwall, England, and came to this country in 1849. Mr. Beckerleg was one of the organizers of the N.A.S.E., and during the forty-one years of the Association's existence, his activities and enthusiasm have remained unabated. In 1882 he was made treasurer, and at the second annual convention in Chicago in 1883 became president. The next year his re-election gave him the distinction of being the only man who has been twice so honored. During his early years Mr. Beckerleg was a locomotive engineer on the Baltimore and Ohio R.R., later engaging in construction work. He was six years with Crane Brothers and was finally connected as salesman with the Dearborn Chemical Co., in which position he remained active until 1918.

Society Affairs

Engineering Foundation announces the results of a recent election of officers. Charles F. Rand was re-elected as chairman; Edward Dean Adams was elected first vice-chairman; Frank B. Jewett, second vice-chairman; Joseph Struthers, treasurer; Henry A. Lardner, assistant treasurer. Alfred E. D. Flinn was re-elected director of the Foundation. Dr. W. F. M. Goss is to succeed George M. Basford and Col. Arthur S. Dwight, Edwin Ludlow on the Foundation Board. Other members of the Board for the coming year are George H. Pegram, Silas H. Woodard, Prof. Herbert M. Boylston, E. Wilbur Rice, Jr., Elmer A. Sperry and J. Vipond Davies. The Executive Committee consists of Messrs. Rand, Adams, Pegram, Jewett and Porter.

Plant Engineers' Club of Boston will hear George Allen, Jr., of the George Allen Co., New York, on "Refractories, Cements, Furnace Design and Maintenance," at a meeting to be held on the evening of March 14. Dinner will be served at 6:30 p.m., at the Boston City Club.

Affliated Technical Societies of Boston, will hold a meeting on March 28 at 7:45 p.m., in Lorimer Hall, Tremont Temple. "Fuel and Power Problems" will be the topic. The following papers will be presented: "Coal" by George B. Harrington, president Chicago, Wilmington and Franklin Co., Chicago; "Oil" by George S. Davidson, president Gulf Refining Co., Pittsburgh, and "Hydro-Electric Power" by Charles W. Kellogg, Stone & Webster, Inc., Boston.

Executive Board of the American Engineering Council, F.A.E.S., will hold a meeting March 23-24 in Cincinnati is announced by the president of the Federation, Mortimer E. Cooley. Government reorganization and reforestration will be among the chief questions discussed by the engineers, who will represent thirty national and local societies.

Personal Mention

Charles H. Bromley has been recently appointed a five-year member of the Constitutional Committee of the A.S.M.E.

J. W. Gardner, of the Gardner Governor Co., is a long way from Quincy, Ill. *Power* has received a pleasant message from him from Cairo and Bombay. May good fortune attend him the rest of the way around.

Frank H. Rudy has withdrawn from the Peabody Engineering Corp., as New England representative and has entered a new company known as the United Engineering Co., 141 Milk St., Boston, dealers in oil-burning equipment for power plants and boiler-room accessories.

Henry F. Russell, formerly with Lumen Bearing Co. and for the last five years sales manager of the iron-foundry department of Farrar & Trefts, Inc., Buffalo, N. Y., has been appointed treasurer and general manager of the Buffalo Smelting Co., Inc., Buffalo.

C. M. Chapman has become consulting materials engineer for Dwight P. Robinson & Co. Mr. Chapman, who has been active in the work of the American Society for Testing Materials and the American Concrete Institute, will represent Dwight P. Robinson & Co. in the committee work of these societies.

Coming Meetings

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Pacific coast regional meeting at Los Angeles, April 16-18; Spring meeting at Montreal, Canada, May 28-31.

American Chemical Society, Gas and Fuel Section; R. S. McBride, Colorado Bldg., Washington, D. C. Motor fuel symposium at New Haven, Conn., April 6.

Society of Industrial Engineers; George C. Dent, 327 S. La Salle St., Chicago, Ill. Spring convention at Cincinnati, Ohio, April 18-20.

American Welding Society, 29 W. 39th St., New York City. Annual meeting at New York City, April 27-28.

American Society of Refrigerating Engineers; W. H. Ross, 154 Nassau St., New York City. Spring meeting at St. Louis, Mo., April 30, May 1-2.

American Association of Engineers, 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

American Water Works Association, 153 W. 71st St., New York City. Annual meeting at Detroit, Mich., May 21-25.

American Boiler Manufacturers Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. 35th annual convention at Hot Springs, Va., June 4-6.

Stoker Manufacturers' Association; J. G. Worker, Eau Claire, Wis. Annual convention at Lake Placid Club, Essex Co., N. Y., May 29-31.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows:

Kansas, at Fort Scott, April 4-6; C. H. Taylor, 517½ W. 6th St., Topeka.

E. J. Morgan has severed his connection with the Worthington Pump & Machinery Corp., to become connected in a sales capacity with the Chicago office of the DeLaval Steam Turbine Co.

N. B. Ambler, J. T. Brusky, Harrison E. Kleffel and **Thomas Richardson** have recently joined McClellan & Junkersfeld, Inc. Mr. Ambler was for the last ten years superintendent of the Toronto Power Co., Ltd., Niagara Falls, Ontario; Mr. Brusky was formerly with Stone & Webster, Inc., and the American International Shipbuilding Corp.; Mr. Kleffel was with the Peabody Engineering Corp., New York City, and Mr. Richardson was with the M. W. Kellogg Co., New York City.

J. F. Boreland, vice-president of the Huhn Manufacturing Co., is on an extended business trip to Japan and Hawaii.

Albert W. Honywill, Jr., has severed his connection with the Terry Steam Turbine Co., Hartford, Conn., to become assistant to the president of the Diamond Power Specialty Corp., Detroit, Mich.

Business Notes

Harrisburg Manufacturing and Boiler Co., Harrisburg, Pa., has recently opened a sales office in the Park Row Building, New York City.

McClellan & Junkersfeld, Inc., announce that Mr. Renshaw Borie is associated with them in their work of engineering, construction, and management, and is in charge of their Philadelphia office at 112 South 16th Street.

Chas. Cory & Son, Inc., at the February meeting of the directors, elected Joseph Jones vice-president, to succeed Franklin Wood. Mr. Jones resigned from the Navy Department (New York Yard) as Senior Electrical Expert Aid in 1919, to become associated with the Cory corporation, a pioneer in the design and manufacture of signal, communicating and lighting equipment for the navy and merchant marine.

Warren Steam Pump Co., Warren, Mass., has opened a New York City office at 1142 Marbridge Building, 34th St. and Broadway.

The Uehling Instrument Co., Paterson, N. J., has appointed John E. Arnold, Tulsa, Okla., as its Oklahoma agent, and H. R. N. Johnson, Minneapolis, as its representative in Minnesota and the Dakotas.

The Geo. T. Ladd Co., Pittsburgh, Pa., has appointed C. M. Decker as sales representative in the Philadelphia territory, with offices at 2128 Land Title Building, Philadelphia.

Trade Catalogs

Furnace Wall Repair—Quigley Furnace Specialties Co., 26 Cortlandt St., New York City. Bulletin No. 53 describing and illustrating a method for reconstructing and patching boiler furnace walls by crushing old firebrick furnace linings and mixing the product with Hytempite.

Reciprocating Engines — Chandler & Taylor Co., Indianapolis, Ind. Bulletin No. 135 describing simple and cross-compound, enclosed, single-valve engines for direct connection to generators.

Easy lessons on the proper burning of soft coal in the home are being distributed in the form of leaflets by the Province of Alberta, Canada, to its citizens. These pamphlets, entitled, "Coal Truths," and written by G. R. Pratt, Fuel Engineer of the Province, form part of a campaign to teach the householder how to burn coal with the least smoke and greatest efficiency.

New Plant Construction

PROPOSED WORK

Ala., East Thomas (Birmingham P. O.)—The St. Louis & San Francisco R.R., Frisco Bldg., St. Louis, Mo., is having plans prepared and will soon receive bids for the construction of a round house, car repair shop, store room, power house, machine shop, mill shop, etc., here. Estimated cost $500,000. R. C. Stephens, Frisco Bldg., St. Louis, Mo., Archt.

Calif., Alhambra—F. I. Lamb, 126 South Cordova St., is having plans prepared for the construction of a 4 story, 145 x 175 ft. hotel and stores building on Main St. Estimated cost $250,000. Scott & Quinton, San Gabriel, Archts. Equipment detail not reported.

Calif., Clarksburg—The Holland Land Co., is having plans prepared by the Engineering Dept. of C. C. Morse Seed Co., 729 Front St., San Francisco, for the irrigation of 1,245 acres of land in Yolo County. Water to be pumped by either a 10 in. or two 8 in. pumps and motors; other pumping plants, concrete pipe lines and ditches will be constructed.

Calif., Oakland—The Elks Hall Assn., c/o W. Knowles, Archt., Bacon Bldg., Oakland is having plans prepared for the construction of an 8 or 9 story lodge, store and office building on 14th St. near Franklin St. Estimated cost $750,000. Equipment detail not reported.

Calif., Roseville—The Pacific Fruit Express Co., 65 Market St., San Francisco, is having plans prepared for additions to its ice plant, here. Cost will exceed $150,000. Private plans. The owner is in the market for $25,000 worth of equipment.

Calif., San Pedro—The Pan-Amer. Petroleum Co., Security Bldg., Los Angeles, plans to build an oil refinery, here, capacity of first unit 30,000 bbl. Cost between $5,000,000 and $8,500,000.

Colo., Denver—The May Co., 16th and Champa Sts., has purchased site and plans to build a 7 story department store, 79 ft. long. Estimated cost $500,000. Engineer or architect not selected.

Del., Wilmington—F. R. Watson, Archt., 1211 Walnut St., Phila., is receiving bids for the construction of a 4 story, 41 x 175 ft. hospital building including steam heating system, on 7th and Clayton Sts., here, for the Sisters of St. Francis, Glen Riddle, Pa. Estimated cost $350,000. Noted Jan. 2.

Fla., Jacksonville—The City Comn., F. H. Owen, Comr. of Public Utilities, will receive bids until Mar. 19 for one 12,000 kw. turbo generator; surface condensing equipment; improvements for surface condensing equipment; admiralty condenser tubes; switchboard additions and improvements for generating and substations; constant current transformers; power transformers; reactors and transformer rewinding material; improvements for boilers and superheaters; oil burners and furnace material; force draft fans; centrifugal boiler feed pump; centrifugal sump pumps; synchronous motors; two storage batteries; lead covered cable and jointing material; copper wire. Scofield Eng. Co., Commercial Trust Bldg., Phila., Pa. Consult. Engrs.

Ga., Newton—The Baker County Power Co. plans to rebuild dam on Ichaway-Nochaway Creek. New head will be approximately 28 ft. J. E. Sirrine & Co., Greenville, Engrs. Noted Feb. 6.

Ind., Peru—The city is receiving bids for a centrifugal pump and motor. J. W. Moore, 834-6 Indiana Pythian Bldg., Indianapolis, Consult. Engr.

Ia., Dubuque—T. J. Mullgrew, 197 Jones St., is in the market for steam driven ice making machinery, large capacity.

La., New Orleans—The Sewerage and Water Bd. A. G. Moffat Secy. will receive bids until April 26, for furnishing 1500-1800 hp. water tube boilers.

Md., Baltimore—The Mayor and City Council have had plans prepared for the construction of a 3 story, 260 x 295 ft. school building, including vapor vacuum heating and ventilating systems, on Calhoun, Carey and Baker Sts. Estimated cost $500,000. H. F. Doeleman, 507 North Charles St., Engr. Owens & Sisco, Continental Bldg., Archts.

Mass., Amherst—The Jones Memorial Library, G. Cutler and J. M. Tyler, Trustees, plans to build a library. Estimated cost $500,000. Engineer or architect not selected.

Mich., Benton Harbor — H. P. Sturges, Archt., 79 West Monroe St., Chicago, is preparing plans and will receive bids early in the spring for the construction of a 3 story golf club and hotel, 100 guest capacity, at Forest Park, here, for the Michicago Club, Otis Bldg., Chicago. Estimated cost $250,000. Equipment detail not reported.

Mich., Detroit — Stratton & Snyder, Archts., 1103 Union Trust Bldg., will soon award the contract for the construction of an 8 story, 90 x 120 ft. shop and club house building, including steam heating boiler and equipment, on Elizabeth St. and Park Blvd., for the Women's City Club, 141 Bagley Ave. Noted Jan. 23.

Mo., Cape Girardeau—A syndicate headed by L. L. Van Dervoort, Vandervoort Hotel, Paragould, Ark., plans to build a 6 or 8 story hotel on Broadway, here. Estimated cost $300,000. Engineer or architect not selected.

Mo., St. Louis—The Fairmont Hotel Co., Chemical Bldg., is having plans prepared for the construction of a 10 story, 147 x 216 ft. apartment hotel building on Euclid St. Estimated cost $500,000. N. Howard, Arcade Bldg., Archt. Equipment detail not reported.

Mo., St. Louis—W. Goldman, 6343 Waterman Ave., is receiving bids and will open same about Mar. 20 for the construction of a 4 story, 126 x 198 ft. stores and theatre building, seating capacity 2,500, on Grand Blvd. Estimated cost $500,000. P. J. Bradshaw, International Life Bldg., St. Louis, Archt. Equipment detail not reported.

Mo., St. Louis—S. Koplar, 5759 Waterman Ave., plans to build a 10 story, 150 x 254 ft. hotel apartment building on Union St. Estimated cost $600,000.

Mo., St. Louis — The St. Louis & San Francisco R.R., Frisco Bldg., is having plans prepared and will soon receive bids for the construction of a repair shop, round house, machine shop, power house, mill shop and store room at Fyler Ave. and Frisco right-of-way. Estimated cost $500,000. R. C. Stephens, Frisco Bldg., Archt.

Neb., Davenport—The Village Clk. will receive bids until Mar. 20 for the construction of one steel tank on steel tower, 4 and 6 in. pipe, valves, fittings, hydrants, 8 in. well, pump and pump house. Estimated cost $25,000. Prince-Nixon Eng. Co., 501 Peters Trust Bldg., Omaha, Engrs. Noted Jan. 30.

N. J., Newark—Salaam Temple, A.A.O. N.M.S., 1020 Broad St., will receive bids until Mar. 14 for the construction of a temple. Estimated cost $1,000,000. F. Grad, 245 Springfield Ave., Newark, Engr. and Archt. Noted Jan. 2.

N. Y., Edwards—The Northern Ore Co., W. R. Wade, Mgr., C. A. Sullivan, Purch. Agt., is receiving bids for a sinking shaft, 1,500 ft. 3 compartments, timbered, first 1,000 ft. gneiss, balance limestone; electric power, hoisting equipment, timbers, compressed-air; drills; drill-steel and blacksmithing furnished.

N. Y., Mamaroneck—E. L. Howe, Village Clk., will receive bids until Mar. 22 for the completion of sewage disposal works, including 2,600 cu.yds. of earth excavation; 1,630 cu.yds. of concrete masonry; completion of machinery building; furnishing and erection of compressors, cast-iron and wrought-iron piping, valves, diffuser blocks, electrical equipment and other work necessary for completion. Fuller K. McClintock, 170 Bway., New York, Consult. Engrs. J. M. Duffy, Village Engr.

N. Y., Penn Yan — The Yates Electric Light & Power Co., F. D. Berry, Dir., have had plans and estimates prepared for the construction of a new electric power plant at Cascade Mill. Estimated cost $500,000.

N. Y., Schenectady—The Bd. of Supervisors of Schenectady County, I. P. Estcourt, Clk., 25 Front St., plans to build a hospital and sanitarium. Estimated cost $500,000. Engineer or architect not selected.

N. Y., Tonawanda—The Town Bd., 2852 Delaware Ave., Kenmore, will receive bids until Mar. 21 for the construction of a sewer system, 105,000 ft., 8 to 48 in., tile, concrete pipe or segmental block; disposal plant; 1 story, 28 x 39 ft. pumping plant; 6 in. pump, 1,200 g.p.m. and 8 in. pump, 2,000 g.p.m. G. C. Diehl, 575 Ellicott Sq. Bldg., Buffalo, Engr.

N. C., Rougemont—W. A. Carver wants prices on turbine water wheel to develop 60 to 80 hp., under 20 ft. head, generator, and governor to control water wheel.

N. C., Salisbury—The Swink Mfg. Co., W. J. Swing, Pres., China Grove, plans to build a cotton mill and develop a town site on 400 acres of land on the Southern Ry., 6 miles south of here, including power and sewer development. Estimated cost $2,000,000.

Ohio, Cincinnati—C. C. and E. A. Weber, Archts. and owners, Ingalls Bldg., are preparing plans for the construction of an 80 x 112 ft. hotel apartment building on Reading Rd., Gholson and Avondale Aves. Estimated cost $700,000. Equipment detail not reported.

Ohio, Cleveland—The Babies & Childrens Hospital, c/o A. Garfield, Natl. City Bldg., will soon award the contract for the construction of a 9 story, 60 x 151 ft. hospital building at 11029 Euclid Ave. Estimated cost $500,000. A. Garfield, Nat. City Bldg., Archt. Equipment detail not reported.

Ohio, Cleveland—The city, Comr. of Purchases & Supplies, City Hall, is in the market for one 600 hp. steam turbine for Fairmount Pumping Sta.

Ohio, Columbus — The Barnhart-Seiller Co., 36 West Gay St., is having sketches made for the construction of a 3 story, 162 x 243 ft. apartment house on 2nd Ave. and High St. Estimated cost $600,000. Engineer or architect not selected.

Okla., Chickasha — The Nichlos Oil & Drilling Co. plans to build a complete pipe line with several auxiliary pumping plants. Estimated cost $300,000.

Okla., Dewey—E. J. Jones is in the market for a refrigeration plant, 1 ton capacity.

Okla., Helana—The city is having plans prepared for the construction of a new well, water pump and extensions to lighting distribution system. J. D. Bomford, 3rd Floor, Masonic Temple Bldg., Enid, Engr.

Okla., Maysville—G. H. Hope is in the market for a 16 x 66 high pressure boiler. A.S.M.E. t

Okla., Oklahoma—The Peerless Boiler & Engine Co., 15 East River St., is in the market for a 150 hp. horizontal tubular boiler.

Okla., Weatherford—The city, R. Dickerson, City Clk., will receive bids until Mar. 27 for the construction of a 500 hp. oil engine power plant, two centrifugal pumps, 20 ton distilled water ice plant, buildings and appurtenances; also equipment to include two 250 hp. oil engine generator sets, two motor driven pump units and one air compressor. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engrs. Noted Feb. 13.

Ore., Portland—The Com. of the Medical Bldg. Assn. will receive bids until about April 15 for the construction of a 12 story office building, including heating and ventilating systems, on Taylor, 10th and 11th Sts. Estimated cost $1,000,000. W. Bruce, Henry Bldg., Archt.

Pa., Ebensburg — The Cambria County Comrs., H. Jones, Controller, are having plans prepared for the construction of a 3 story hospital. Estimated cost $250,000. W. R. Myton, 1204 1st Natl. Bank Bldg., Johnstown, Archt. Equipment detail not reported.

Pa., Franklin—The Franklin Hospital is in the market for mechanical laundry and refrigerating equipment.

Pa., Hazelton—The Jeddo-Highland Coal Co. plans to build a power house at its No. 2 colliery. Estimated cost $25,000.

Pa., Phila.—L. B. Rothchild, Archt., 145 South Broad St., is receiving bids for the construction of a 12 story office building, at 1019-23 Arch St., for W. Goldstein, c/o

Archt. Estimated cost $700,000. Equipment detail not reported.

Pa., Johnstown — The Johnstown School Dist., S. J. Slawson, Supt., W. E. Shissler, Secy., plans to build a 3 story, 200 x 200 ft. Senior High School on Somerset St. Estimated cost $1,000,000.

Pa., Scranton—The West Park Methodist Episcopal Church, Oram St., F. P. Doty, Pastor, plans to build a boiler room addition to its church edifice and is in the market for large boiler and equipment.

S. D., Capa—The Capa Hydro-Sanitarium, c/o T. S. Hansen, is having plans prepared for the construction of 3 units of a sanitarium, each 2 story, 120 x 124 ft., to consist of hotel, hospital, theater, gymnasium, etc., including steam heating system. Estimated cost $250,000. J. C. Ewing, Rapid City, Archt.

Tenn., Dandridge — Bush Bros., contractors, are in the market for a 20 hp. engine, 100 hp. boiler, shafting and belting.

Tex., Granbury—The city, A. T. Keith, Mayor, plans election March 20, to vote $28,000 bonds for the construction of an electric light plant. New machinery will be needed.

Va., White Sulphur Springs—The White Sulphur Springs Co. is having plans prepared for the construction of a 7 story, 180 x 380 ft. hotel. Estimated cost $700,000. Elzner & Anderson, Citizens Natl. Bank Bldg., Cincinnati, O., Archts. Equipment detail not reported.

Va., Wytheville—R. P. Johnson is in the market for a 40 hp. boiler and a 25 hp. engine.

W. Va., Clarksburg—The Consolidated Power & Light Co. plans the construction of extensive improvements and additions to lines and generating plants. Cost will exceed $25,000.

W. Va., Huntington — The Coal Exch. Bldg. Co., c/o A. Solof, 1107 4th Ave., is having plans prepared for the construction of a 14 story, 60 x 114 x 170 ft. stock exchange and office building on 4th Ave. and 11th St. Estimated cost $750,000. Meanor & Handloser, R. & P. Bldg., Archts. Equipment detail not reported.

W. Va., Parkersburg—The Kesterson Ice Co. plans to build an ice plant. Estimated cost $50,000. Engineer or architect not announced. The owner is in the market for ice manufacturing machinery and equipment.

W. Va., Wellsburg—The city has retained Hudson & Myron, Engrs., Wabash Bldg., Pittsburgh, Pa., to prepare comprehensive report, plans and to supervise the construction of filter plant, new pump installation and other improvements for waterworks.

Wis., Foxlake—The North Amer. Casket Co., c/o W. C. O'Connell, manufacturer of caskets, toys, etc., is in the market for motors.

Wis., Green Bay—M. Tullgren & Sons, Archts., 425 East Water St., are receiving bids for the construction of the superstructure of an 8 story, 130 x 160 ft. hotel on Pine St., here, for the Hotel Wisconsin Realty Co., 86 Michigan St., Milwaukee. Estimated cost $850,000. Equipment detail not reported. Contract for foundation awarded. Noted Jan. 9.

Wis., Milwaukee—O. Brachman, 425 East Water St., is having preliminary plans prepared for the construction of a 9 story, 100 x 150 ft. hotel on Wells St. Estimated cost $900,000. M. Tullgren & Sons Co., 425 East Water St., Engrs. and Archts.

Wis., Milwaukee — Cahill & Douglass, Engrs., 217 West Water St., are receiving bids for two (72 in. x 18 ft.) 150 hp. tubular boilers and 150 kw. engine generator set, for the Western Leather Co., 787 Marshall St. Noted March 6.

Wis., Milwaukee—The Hotel Medford, 3rd and Sycamore Sts., is having plans prepared for the construction of a 4 story, 75 x 120 ft. addition. Estimated cost $450,000. C. Barkhausen, 79 Wisconsin St., Archt. Equipment detail not reported.

Wis., Milwaukee—Milwaukee Elks Lodge, 448 Jefferson St., and R. A. Messmer & Bro., Archts., 221 Grand Ave., are receiving bids for the construction of the superstructure of a 9 story, 110 x 145 ft. club house on Juneau Pl. Estimated cost $1,000,000. Equipment detail not reported. Noted Aug. 15.

Wis., Milwaukee — The Realty Improvement Co., c/o O. Brachman, 425 East Water St., is having preliminary plans prepared for the construction of a 7 story, 50 x 150 ft. office building on Wells St. Estimated cost $500,000. M. Tullgren & Sons Co., 425 East Water St., Archts.

Wis., Seymour—M. G. Hallada is in the market for refrigeration machinery, several ton capacity.

Wis., Wauwatosa — The Bd. of Public Wks., A. V. Brigham, Secy., will receive bids until Mar. 16 for furnishing and erecting on 1,000 g.p.m. centrifugal pump or turbine connected to 220 volt, 3 phase, 60 cycle electric motor.

Ont., Capreol—The town, A. Brundage, Clk., plans to install a waterworks system and fire protection service, including centrifugal pumps, cast iron mains, hydrants, valves, pumphouse and reservoir. Estimated cost $50,000. Engineer not selected.

Ont., Hamilton—The United Gas & Fuel Co., R. A. Foley, Engr., is receiving bids for the construction of 15 coke ovens and plant, including complete equipment. Estimated cost $2,000,000.

Ont., Timmins — The Northern Canada Power Co., Timmins, J. H. Black, Gen. Mgr., 36 Toronto St., Toronto, plans to install a fourth hydro-electric power plant, 5,000 hp. 70 ft. head, on the Mattagamie River at Kenogamissee Falls. Equipment including turbines, generators, electrical equipment, transformers, transmission line, etc., will be required.

Ont., Tillsonburg—The Norfolk Shoe Co., L. C. Greel, Supt., is in the market for electric motors for proposed factory.

Ont., Toronto—The city plans to install an 80,000,000 imperial gal. pump, electric or steam, 3 stage, in the main pumping station. Estimated cost $113,122. R. C. Harris, City Hall, Engr.

CONTRACTS AWARDED

Calif., San Francisco—The Huntington Apartments, 114 Sansome St., E. B. DeGolia, Pres., awarded the contract for the construction of a 12 story apartment building on Taylor and Calif. Sts., to Cahill Bros., 110 Sutter St. Estimated cost $1,300,000. Equipment detail not reported.

Conn., Bridgeport—The New Haven Dairy Co., 201 Hazel St., New Haven, awarded the contract for the construction of a 3 story, 75 x 85 ft. ice cream plant on Garden St. and South Ave., here, to the T. J. Pardy Constr. Co., 1481 Seaview Ave., Bridgeport. Estimated cost $150,000. The owner is in the market for ice making and ice cream equipment. Noted Jan. 23.

Conn., New Haven — Yale University awarded the contract for the construction of a 3 story, 70 x 170 ft. field club building on the campus to the F. T. Ley Co., Inc., 499 Main St., Springfield, Mass. Estimated cost $500,000. Steam heating system will be installed.

Ind., South Bend—The Studebaker Corp., Main and Bronson Sts., awarded the contract for the construction of a 6 story, 100 x 820 ft. automobile body plant, including steam heating equipment, on Lafayette Blvd., to the H. G. Christman Co., 315 Stevens Bldg., Detroit, Mich.

Mass., Warren—The city awarded the contract for the construction of a water works system, including pumping plant, wells, etc., to the Hanscom Constr. Co., 141 Milk St., Boston, Mass. Estimated cost $200,000. Noted Nov. 21.

Mich., Detroit—The Donovan Bldg. Co., c/o A. Kahn, Archt., 1000 Marquette Bldg., awarded the contract for the construction of a 10 story, 60 x 200 ft. store and office building on Woodward Ave. and Duffield St., to A. A. Albrecht, 1130 Penobscot Bldg. Steam heating plant, boiler and equipment to be installed.

Minn., Chisholm—The Bd. Educ., c/o J. P. Vaughn, awarded the contract for the construction of a 3 story, 200 x 402 ft. Junior High School to J. and W. A. Elliott, Lumber Exch. Bldg., Minneapolis. Estimated cost $562,933. Steam heating system will be installed. This corrects report in Feb. 13 issue.

Miss., Gulfport—The Bureau of Yards & Docks, Navy Dept., Wash., D. C. awarded the contract for the construction of U. S. Veterans' hospital buildings to A. Blair, Montgomery, Ala., $498,580. Water, sewer and drainage to Hamilton Bros. Co., Gulfport, $45,802. Inside heating and outside steam etc., to W. Wilby, Selma, Ala., $60,621. Electric work to H. Andrea Electrical Co., 136 Second St., Milwaukee, Wis., $25,022. Boiler house to F. J. Eisinger, Brooklyn, N. Y., $53,594. Noted Feb. 6.

N. J., Newark—The B. P. O. E., 27 Green St., awarded the contract for the construction of a club house on Broad and Camp Sts., to the D. W. McGee Constr. Co., 142 1st St., Newark. Estimated cost $1,135,085. Equipment detail not reported. Noted Nov. 21.

N. Y., New York—The Schneider Holding Co., c/o W. Koppe, Archt. and Engr., 567 East Tremont Ave., will build a 6 story, 150 x 200 ft. apartment house on Mott Ave. near 156 St. Estimated cost $700,000. Equipment detail not reported.

N. Y., Youngstown—The Chemical Cold Storage Co. awarded the contract for the construction of a 100 x 100 ft. cold storage plant, 31,000 bbl. capacity, to Laur & Mack, Highland St. and College Ave., Niagara Falls. Estimated cost $100,000.

Okla., Wynnewood—The city awarded the contract for the construction of a 350 hp. power plant, 150,000 gal. elevated tank, 2 mile pipe line, two wells, electric distribution system, transmission line and pumping equipment, consisting of two 150 g.p.m. Remsey triplex pumps, motor driven, to the Sherman Machine Co., 18 East Main St., Oklahoma City. Estimated cost $61,263.10. Noted Feb. 27.

Ore., Oregon City — The Crown Willamette Paper Co., A. J. Lewthwaite, Mgr., 736 Pittock Blk., Portland, will build by day labor, new acid system paper mills, also additions and repairs to old plant. Estimated cost $250,000. Owner is in the market for engines, boilers and acid system paper mill machinery.

Pa., Easton—The Binney & Smith Co. awarded the contract for the construction of a 4 story, 80 x 100 ft. manufacturing plant and 250 hp. power house, to Brillhart Bros., Bethlehem. Noted Jan. 9.

Pa., Pittsburgh—The Bd. Educ., Fulton Bldg., awarded the contract for the construction of a 3 story, 140 x 300 ft. addition to high school on Margaretta and Beaty Sts., to the P. H. Kelly Co., Sanson St., Phila.; heating and ventilating, Ryan Heating Co., 53 Tunnel St., Pittsburgh, $90,652; fans, Hersh Bros. Co., Federal Reserve Bldg., Pittsburgh, $2,886; boilers, Burnell Furnace Wks., Park Bldg., Pittsburgh, $13,000; motors, Wagner Electric Co., 530 Fernando St., Pittsburgh, $1,020. Noted Jan. 30.

Pa., Zelienople — The borough awarded the contract for the construction of a 1 story, 21 x 36 ft. filter building; two 300,000 gal. per day, mechanical filter units and auxiliaries; one 350 g.p.m. motor driven centrifugal low lift pump to W. J. Maglaughlin, Park Bldg., Pittsburgh. Estimated cost $25,000. Noted Jan. 30.

S. C., Clover—The city awarded the contract for the installation of complete sewer system, 10 mi. of pipe, 3 disposal tanks and improvements to pumping station to W. A. Ebert, Latta Arcade, Charlotte, N. C. Estimated cost $65,000. Noted Jan. 23.

Tex., Dallas—The Dallas Athletic Club, L. L. Monagan, Secy., awarded the general contract for the construction of a 14 story, 200 x 300 ft. club building on Elm, St. Paul and Live Oak Sts. to the Central Constr. Co., Deere Bldg., Dallas. Estimated cost $1,500,000. Other contracts not awarded. Noted May 3, 1921.

Wash., Tacoma—The City Light Dept. will build a substation to serve the South Tacoma district. Estimated cost $45,000.

W. Va., Glen White—The E. E. White Coal Co. awarded the contract for the construction of a tipple to the Link Belt Co., Huntington Park, Phila., Pa. Estimated cost $75,000. The owner is in the market for motors.

Que., Montreal—The Provincial Govt., A. Galipeault, Minister of Pub. Wks., awarded the general contract for the construction of the new court house annex on Notre Dame St. to Alphonse Gratton, Ltd., Maisonneauve St., and the Atlas Constr. Co., Ltd., Belmont St., jointly, $1,943,560. Plumbing, heating and ventilating to J. Ballantyne, 163 Nazareth St., $216,987. Electrical installation to Canadian Comstock Co., Cathcart St., $21,900.

Que., Quebec — The Quebec Development Co., Ltd., awarded the contract for the purchase of $1,500,000 hydraulic machinery to be utilized in the development of 1,000,000 hp. at a dam on the Saguenay River, to the Canadian Allis Chalmers Co., Ltd., 162 St. Antoine St., Montreal. Noted Dec. 12.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances—Wrought-iron pipe discounts down four points on black and six on galvanized on Pittsburgh basing card. Steel structurals at $3.44 as against $3.29 per 100 lb., one month ago in New York. Cold finished steel advanced 15c. per 100 lb. in New York and Cleveland warehouses. Portland cement rose 10c. per bbl. in New York during month. Cotton waste and wiping cloths higher in Cleveland. Linseed oil $1.01 in New York as against 96c.; $1.06 in Cleveland, up from $1.01 and $1.07 in Chicago, as compared with $1.02 per gal. (5 bbl. lots), last month. Discounts on brass-shell sockets and armored cable down five points since February. Flexible cord and conduit prices higher.

Declines—Chrome and magnesite brick, and chrome cement slightly lower during month. Reductions reported on elbows and couplings in New York market.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in., coupled		50c. per ft.
Common, 2½-in., 3-ply		1.00 per ft. list less 50%

	Air	
	First Grade	Second Grade
¾-in., 3-ply, per ft.	$0.31	$0.22½

Steam—Discounts from List

First grade....40–10–5% Second grade....50% Third grade....50–10%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 65% Best grade..... 60%

LEATHER BELTING—List price per ply, 12-in. wide, per lin. ft. $2.88

Grade	Discount from list
Medium	30–10%
Heavy	20–5–2½%

RAWHIDE LACING { For cut, best grade, 40%, 2nd grade, 50%. For laces in sides, best, 48c. per sq.ft.; 2nd, 43c. Semi-tanned: cut, 40%; sides, 48c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ½ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		40@45%
For low-pressure heating and return lines	4-ply	66⅔%
	3-ply	70%
	2-ply	72%

PORTLAND CEMENT—New York, $2.70@$2.80 per bbl. without bags, in cargo lots delivered on job. Bag charge or 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.44 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	10.00@13.00	15.00	11.25
Mixed	7.00@12.00	12.00	8.00

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13½ x 13½	13½ x 20½
Chicago	10.00	13.00
New York	16.00	20.00
Cleveland	$36.00 per M.	$52.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.01	$1.06	$1.07

WHITE AND RED LEAD—Base price in cents per pound:

	Red—Current		Red—1 Year Ago		White—Current	White—1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry or In Oil	Dry or In Oil
100-lb. keg	14.25	15.75	12.25	13.75	14.25	12.25
25- and 50-lb. keg	14.50	16.00	12.50	14.00	14.50	12.50
12½-lb. keg	14.75	16.25	12.75	14.25	14.75	12.75
5-lb. cans	17.25	18.75	15.25	16.75	17.25	15.25
1-lb. cans	19.25	20.75	17.25	18.75	19.25	17.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel 7/16 and smaller	45%	60%	60%
Tinned	50%	60%	4½c. per lb. net

Structural rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York.....$3.85 Chicago.....$3.75 Pittsburgh... $3.00

Boiler rivets, same sizes:

New York.....$3.95 Chicago..... $3.85 Pittsburgh... $3.10

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$50@53
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	25@30
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	29@34
Magnesite brick: 9-in. shapes	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Chicago district	per M	50.00
Silica brick: Birmingham, Ala.	per M	49.00
Silica brick: Mt. Union, Pa.	per M	45.00
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	43@50
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	40@45
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	40@45
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	38@45
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	35@40
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	37@40
Chrome ore crude, 45@50%	net ton	24.00
Magnesite dead burn	net ton	38.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	42.00	49.25	36.00
(35% tin)	25.00	18.00	.....

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting and screw stock, per 100 lb. base	$4.20	$3.95	$3.90
Flats, square and hexagons, per 100 lb. base	4.70	4.45	4.40

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	64	52½	¼ to 1¼	30	13

LAP WELD

2	57	45½	2	23	7
2½ to 6	61	49½	2½ to 4	26	11
7 to 8	58	45½	4½ to 6	28	13
9 and 12	57	44½	7 to 12	26	11

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	62	51½	¼ to 1½	30	14
2 to 3	63	52½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	55	44½	2	23	9
2½ to 4	59	48½	2½ to 4	29	15
4½ to 6	58	47½	4½ to 6	28	14
7 to 8	54	41½	7 to 8	21	7
9 to 12	48	35½	9 to 12	16	2

OILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2½	.23	.29	.23
2½	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3½	.32	.47	.35
3½	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¾ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 45.00 (net)	$67.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	30%	15%
Coils to 1,000 ft.	35%	20%
1,000 to 5,000 ft.	40%	25%
5,000 ft. and over	45%	30%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
½	59.99	64.09	9.96	11.10	5.56	5.98
¾	75.21	82.11	13.10	14.60	7.94	8.54
1	107.78	117.98	19.39	21.61	10.32	11.10
1¼	145.82	159.62	25.83	28.53	14.35	15.37
1½	174.35	190.35	34.44	38.04	17.72	18.98
2	234.58	256.78	63.14	69.74	23.63	25.31
2½	370.89	405.99	103.32	114.12	33.76	36.16
3	485.01	530.91	275.52	304.32	50.74	54.24
3½	610.88	666.08	608.44	672.04	67.52	72.32
4	745.56	810.96	703.15	776.65	84.40	90.40

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.09	D. P. D. B.	$0.27
D. P. M. L.	.14	T. P. S. B.	.26
T. P. M. L.	.20	T. P. D. B.	.39
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.39	$1.26	$1.31
T. P. M. L.	.55	1.47	1.89
D. P. S. B.	.49	1.26	.....
T. P. S. B.	.92	2.10	.....
D. P. D. B.	.89	2.46	.....
T. P. D. B.	1.57	4.20	.....
T. P. to D. P. D. B.	1.05	2.88	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$22.00
No. 16 cotton reinforced heavy	30.50
No. 18 cotton reinforced light	18.25
No. 16 cotton reinforced light	22.57
No. 18 cotton Canvasite cord	16.00
No. 16 cotton Canvasite cord	18.50

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$.20	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	0.30	35-amp. to 60-amp.,	100	.60
265-amp. to 100-amp.,	50	2.90	65-amp. to 100-amp.,	50	1.50
210-amp. to 200-amp.,	25	3.00	110-amp. to 200-amp.,	25	2.50
425-amp. to 400-amp.,	25	5.60	225-amp. to 400-amp.,	25	5.50
25-amp. to 600-amp.,	10	.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.70
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs — Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.40	100	75	$0.60	$0.65	50
15	.35	.40	100	100	.75	80	24
25	.35	.40	100	150	1.00	1.10	24
40	.35	.40	100	200	1.30	1.40	24
50	.35	.40	100	300	1.90	2.00	24
60	.40	.45	100				12
				500	2.75	2.90	12
				750	4.00	4.25	8
				1,000	4.50	4.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.17
Composition 2-piece attachment plug	.26
Swivel attachment plug	.12

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 7.08	$ 8.98	$11.25	$17.92
12	9.79	11.90	14.08	23.41
10	12.84	14.69	17.92	30.43
8	17.26	20.11	23.64	40.69
6	.....	.....	35.73	.....
4	.....	.....	48.15	.....
2	.....	.....	73.00	.....
1	.....	.....	97.55	.....
0	.....	.....	121.08	.....
00	.....	.....	143.67	.....
000	.....	.....	172.63	.....
0000	.....	.....	206.38	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap — Key Each	Keyless Each	Pull Each	¾ In. Cap — Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	10%
1-5th to standard package	22%
Standard package	38%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	25c. lb
Soldering paste, 2 oz. cans	$1.00 doz

ENCLOSED SWITCHES, KNIFE—Externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	25%
$25 to $50 list value	30%
$50 list value or over	35%